Teacher's Manual for

OUGH THE YEAR

The HOW AND WHY Science Books

A TEACHER'S MANUAL
AND SCIENCE HANDBOOK
to accompany

THROUGH THE YEAR

BOOK I

of the

HOW AND WHY SCIENCE SERIES

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THE HOW AND WHY SCIENCE BOOKS

- WE SEE (PRE-PRIMER)
- SUNSHINE AND RAIN (PRIMER)
- THROUGH THE YEAR (GRADE 1)
- WINTER COMES AND GOES (GRADE 2)
- THE SEASONS PASS (GRADE 3)
- THE HOW AND WHY CLUB (GRADE 4)
- HOW AND WHY EXPERIMENTS (GRADE 5)
- HOW AND WHY DISCOVERIES (GRADE 6)
- HOW AND WHY EXPLORATIONS (GRADE 7)
- HOW AND WHY CONCLUSIONS (GRADE 8)

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"All knowledge begins in wonder."

ELEMENTARY SCIENCE

THE PHILOSOPHY OF SCIENCE TEACHING

Someone has said, "All knowledge begins in wonder." A child entering school for the first time brings with him spontaneous enthusiasm and interest in the world about him which manifest themselves in an eagerness to relate his experiences. He is full of questions about the caterpillars, frogs, turtles, and other live things that he finds as he plays. He is curious about the weather, the heavenly bodies, and other physical phenomena of his environment. He asks how and why the mechanical devices of his everyday experiences work.

Too often this natural curiosity of the little child is lost instead of being developed during the first few years of school life, because teachers and parents feel their inadequacy to meet the situation. The knowledge required to answer all these questions is so great as to discourage the average adult. When children are curious, they have no respect for the lines of subject matter. One question may fall in the field of biology; the next in physics or chemistry. To

answer all questions completely might well require more knowledge than even a specialist would possess.

However, to teach science to children it is not necessary to be able to answer all their questions. The alert teacher with abundant enthusiasm and curiosity can help them find the answers to many of their own questions. Nowhere will her efforts bring more satisfying results than in the teaching of science.

The philosophy of science teaching differs very little from that of any other subject. It is the subject matter which makes the handling of it more difficult, because teachers are not generally trained for science teaching. The teacher must take into account those things in the child's experience which lie in the field of science. There are many experiences common to children everywhere that may become the foundations of our science work. From these common paths teachers may diverge with the interests of individuals and the groups, and adapt the teaching to the local community or section of the country.

We live in a world that is changing so rapidly that what is grist for the science mill today may become a waste product tomorrow. One day a Byrd explores Antarctica; a Beebe explores the depths of the ocean; or a Piccard penetrates the stratosphere. At such times even first-graders may discuss the stratosphere but to put the stratosphere into a first-grade book, in the light of our present knowledge, would be questionable.

Again, the children we teach are affected by varied environments. Those of the western plains have a whole set of animal concepts not possessed by children of the Atlantic coast. Children in a mining town, children from the country, children from a metropolis—all have experiences which give them different ideas. But through all these experiences the teachers may teach the same scientific principles. For example, hibernation of animals may be taught to a western child by a study of snakes; to a child in the lake region by a study of frogs; to a child somewhere else by the study of clams, crayfish, or some insect.

In science, the teacher needs to remember individual differences. Some children respond more freely to experiences with plants, some to animals, some to physical science. By encouraging children to express themselves freely in the classroom, and to experi-

ment for themselves with the materials found in the science room, the teacher can discover these differences and make effective uses of them.

Above all, to be a successful teacher of science, one must be enthusiastic about the subject, enjoy working with children, and understand the way they think. She must be scientific in her own attitudes and be able to use the problem-solving method of teaching. She does not have to be a specialist in science nor be afraid that she won't know all the answers. She probably won't be able to answer all the questions which the children ask, but even if she can, to do so would spoil the fun for the children. She need not hesitate to say, "I don't know," providing she continues, "but we'll find out together." Science teaching can be a shared experience of teacher and children that has great possibilities for both.

OBJECTIVES FOR TEACHING SCIENCE TO CHILDREN

Science for the grades should not be regarded as a mere accumulation of facts but as a series of experiences with the science materials that are a part of every child's daily life. These experiences stimulate the curiosity of children and if used properly should lead to behavior changes in the children. To accomplish desirable outcomes the teacher should understand the reasons why anyone studies science. These reasons may be called objectives. Scientists differ in the way they state these major objectives, but they agree on their content. Briefly stated, these objectives of elementary science are:

1. To develop an intelligent appreciation of the natural and physical world.
2. To develop scientific attitudes.
3. To help the child acquire the scientific method of problem solving.
4. To help the child acquire useful knowledge of scientific principles.

By an intelligent interest and appreciation of the world in which he lives, a child is made aware of real beauty that goes deeper than

the mere appeal to sense. Appreciation grows as knowledge is gained. The person who gets a satisfaction from the color and form of a beautiful butterfly should enjoy it more after seeing it go through its transformation from pupa to adult. The child who, looking intently at a butterfly's chrysalis, exclaimed, "Oh, I can see the wings through the chrysalis skin!" was experiencing appreciation. Children should get a thrill out of their science experiences which will make their lives richer and more enjoyable.

Appreciation should lead to the conservation of wild life. The biological principles of the struggle for existence and survival of the fittest make for a balance in nature, unless it is upset by man. Through experiences with material such as that used in "Insects in the Garden," "Birds in the Orchard," and "Life in the Pond," children may be led to see the relationships of plants and animals. They learn which ones are harmful, and what to do about them, as well as which ones are helpful to man.

The second objective, that concerning scientific attitudes, should run through all science teaching. The child who has these scientific attitudes:

(*a*) Will have a conviction of basic cause-and-effect relation which will make it impossible for him to believe in superstition or unexplained mysteries.
(*b*) Will have a sensitive curiosity which will lead to making accurate observations, collecting data, and searching for adequate explanations.
(*c*) Will have the habit of delayed response, preventing him from making snap judgments or jumping to conclusions.
(*d*) Will weigh evidence carefully to find out if it is sound, pertinent, and adequate.
(*e*) Will have respect for another's point of view, being willing to change his point of view in the face of new evidence.

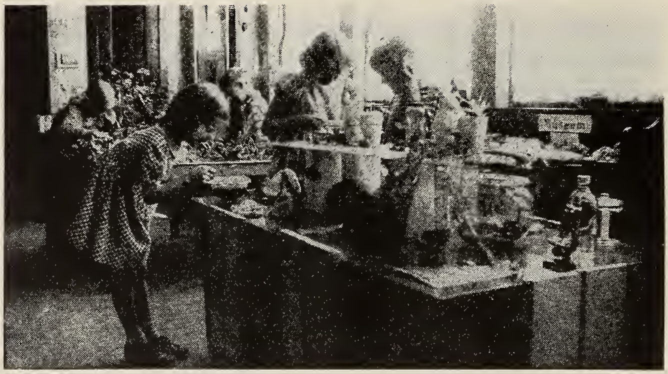
These may sound formidable to the teacher who has had little training in science. She may recognize them as desirable outcomes, yet not have the slightest idea of how to go about teaching them. She need not be frightened, however, because the techniques by which she helps children develop scientific attitudes are

very similar to those she uses to develop social attitudes. The first step is to be able to recognize a *lack* of the attitudes.

For example, a child who says, "My grandmother says the ground hog saw his shadow and he can tell about the weather," does not have the attitude of looking for a cause. The teacher could help him develop the attitude by saying, "That is interesting. I wonder what makes your grandmother think that," or, "I wonder what the ground hog (woodchuck) knows." The child may answer, "If he sees his shadow on ground-hog day, we'll have six weeks of bad weather." Then the teacher may say, "That may be true, but what do the rest of you think about it?" After a brief discussion she may say, "All of you are just giving ideas. Is that the way scientists (or people who study woodchucks) would settle a question?" The children may suggest watching for woodchucks or discussing the weather on February 2—will the woodchuck see his shadow or not? They may watch the weather for six weeks, recording it and comparing the actual weather with the woodchuck's "prediction." Some child may be bright enough to remark, "It may be cloudy in the fields south of town and the sun may be shining on the north side. The north side couldn't have six weeks of bad weather while the south side is having good weather." The grandmother (who would have resented it had the teacher said, "That idea is not true, Tom,") may become interested in a long-time experiment; but, whether or not there is hope for grandmother, Tom's plastic mind has been affected by six weeks of observing and checking.

Later when Dick insists that horsehairs turn into snakes, Tom will be eager to bring rain water and a horsehair to find out if Dick is right. Bit by bit, these experiences will straighten out Tom's thinking until one day he will say, "I don't believe in superstitions. One day when we were out driving, a black cat ran across the road. Later we had engine trouble, but the trouble was caused because a part had worn out."

Not only is this attitude taught by correcting existing superstitions and misconceptions, but it impels children to look for the causes of all natural phenomena. Numerous opportunities arise every day to develop it. For example, in trying to solve the problem of why food spoils, the teacher may ask, "Where does your



Independent investigations.

mother put food that she wants to keep?" Through discussion someone may say, "Temperature will affect food. When food gets hot, it spoils." In problem solving there are many opportunities to teach scientific attitudes.

The ability to interpret natural phenomena correctly does away with unreasoning fears. The child who understands the cause of thunder, and has demonstrated it in a small way by clapping his hands, is not so likely to be afraid of the noise. Knowing that animals are not likely to sting or bite except in self-defense, he is less susceptible to the fear carried by many people into adult life. The person who has studied about meteors and northern lights doesn't assign mysterious reasons or results to these natural phenomena. The child's understanding of the cause and prevention of disease helps keep him from carelessly exposing himself and others, as in the case of colds. He learns that everything has a cause; that disasters don't just happen, nor, as was once believed, are they visited upon us as punishment.

Curiosity concerning their environment is natural to children, though some have more of it than others. But sensitive curiosity may have to be taught. Children ask many questions to which they really don't expect an answer, nor care for one. Sensitive

curiosity is demonstrated by a perseverance on the part of the child in asking a question, or in independent investigation on his own initiative. Children should be given opportunities to tell of things they observe that stimulate their interest and curiosity. If learning is dependent upon desire to know, then curiosity is a valuable attitude to develop. Some children have it to such a degree that no amount of squelching on the part of adults will stop their investigations. They learn in spite of their teachers. Other timid ones stop asking when they get no satisfactory explanation. The child who persisted in saying, "I *want* to *know* what makes the bubbles in cake," after the teacher had told her it was too hard for her to understand, had unquenchable curiosity.

The ability to make careful, accurate observations and the ability to collect data are outcomes of the attitude of sensitive curiosity. Some teaching techniques which help in the teaching of this attitude are:

(*a*) Making use of the children's suggestions of ways to collect data—for example, when Mary wonders what will happen if a prism is held in a cloud of dust while a sunbeam is striking it, let Mary try it, using chalk dust.

(*b*) Insisting upon accurate descriptions when a child reports having seen something—for example, when a boy describing an insect the size of a gnat, tells of a yellow stripe around its body, the teacher may say, "Just a minute. How could you see the yellow stripe on an insect no larger than a gnat? Tell just what you saw. If you didn't see the color, don't tell about it."

(*c*) Setting an example of collecting data by asking questions about many points which the children have not mentioned in their descriptions.

(*d*) Insisting upon experimentation or demonstration being directed to the purpose of gaining adequate explanations. Children are likely to become more interested in the working of the apparatus than in the answer to their original question. Then the teacher may say, "Why are we doing this experiment? Is it helping to answer the question? It is an experiment only as long as you are learning. After that it is play."

The attitude of delayed response is developed by insisting on the children's not "jumping to conclusions." The child who says, "I saw a bird. I *think* it was a woodpecker because it was tapping on a tree," or "I *think* the fish died because we didn't put any green stuff in the aquarium like we do at home," or "I'm *not sure,* but I don't think the air does all of the work of holding the plane up," has developed the attitude. The child who says, "I *know* that was a fallen star. There are a lot of them around here," hasn't developed the attitude.

To help develop the attitude of delayed response, the teacher must be on the alert with answers such as:

"We must be careful and not think we have found out something when we really haven't."

"Do you think you should say they are fallen stars? Has anyone proved it?"

"Let's save that question and answer it later. Then we will find out more about it to help us be sure." (And don't forget to do it!)

Having developed the attitudes of basic cause and effect, sensitive curiosity, and delayed response, children are ready for weighing evidence. Children are usually eager to express their ideas without thought as to whether they are pertinent or sound. When the teacher is just starting her science program, she may encourage expression to get things under way. After the ice is broken and the children are no longer inhibited or shy, the teacher has to curb their enthusiasm and direct their thinking.

To do this without breaking their line of reasoning takes skill. The teacher must not be discouraged if her first attempts at developing attitudes result in confusion. She may have to go back to the beginning of the lesson and start over. When this happens, the teacher should take the children into her confidence by smiling and saying, "I guess I got us off on the wrong track. Let's see where we were," or "We're all mixed up. You'll have to help me. What were we trying to find out?" The children will respond to this.

Some ways to help develop this attitude of weighing evidence are to give suggestions like:

"Let's remember not to take too much time with details that don't really have anything to do with our problem."

"Does your question have anything to do with electricity? Have you thought it through?"

"Do you think that we have enough information to answer the question?"

"Should we decide before we know what a scientist has to say about that?"

"Let's keep our minds on one track."

By consulting an authority, the teacher should check often on the accuracy and soundness of the experiments being done. The children should check with their science text. They should never draw conclusions from one experiment.

A child who has developed this attitude will say things like this: "I think the tooth comes from the upper jaw by the way it curves. If you'll look at a dog's teeth, you'll notice that the upper teeth curve down over the lower teeth. It's hard to tell whether it's the upper tooth of a big bear or the lower tooth of a small bear," or "We haven't read it carefully enough. He forgot to use a marker so I don't think it would be right."

Willingness to change one's opinion in the face of new evidence is the most advanced attitude of all. The person who has it is tolerant, without prejudice and bigotry. If all the children in the world could really be taught this attitude so that it would function, wars would cease. Science has no monopoly on this attitude, but it offers an excellent opportunity for its natural development. In social studies areas, emotions are more likely to be involved. In solving science problems, children can be more objective. The teacher may say:

"There is a sentence on that page that isn't exactly scientific. Scientists have found out more about it since the book was published."

"When one has the floor, let's remember that others want to talk also, and not take too much time."

"Don't laugh. I'm not surprised that he's mixed up. Grown folks get mixed up, too."

"Do we laugh at people who have ideas?"

"Let John have his chance. Let's listen to what he has to say."
"I think he has an idea, but it just isn't very clear."
"Evidently there are three people who do not agree."
"Jane listened to you; now it is her turn."

Allow every child an opportunity to tell one thing he has observed or learned from an experiment. Give careful consideration to every child's serious question or attempt to explain something. If the teacher respects children as individuals, respects the importance of their problems, and is willing to change her own mind when she sees that she is wrong, it will help in teaching this attitude.

The child who has this attitude will say, "I don't quite agree with her because I think there is a change in the temperature of the land," or "I thought the candle wick burned, but now I know that it is the gas that burns."

Children often have pretty definite ideas about their experiences and are not willing to change those ideas. For example, many people use widely advertised products in their homes without investigating their true value. One science group made a study of some of these products and discovered that the advertising was misleading. The children in the group were learning to evaluate and test statements in the light of evidence.

Willingness to change opinion, to search for the whole truth, and to base judgment on fact are all closely related and may be developed together. They may all result from a comparison of experimental data or accurate observations.

A child may have formed some incorrect idea that he has heard or read in a book. For example, a child insisted that "beavers carry mud on their tails" because he had read it in a children's storybook. The other children challenged his statement. The teacher asked how they could know whether or not the statement was correct. The children said to ask a scientist or look it up in several books written by scientists who had studied beavers. When this was done, the child who had made the statement saw that his idea was wrong. He also realized that he could not believe everything he read.

Many elementary teachers have themselves not had the advantage of science training and do not know how to teach by the problem-solving method. Although it is not unique to the field of science, the average elementary teacher may not have learned the techniques necessary to help children learn it and use it. Even if teachers have used problem solving in teaching social studies or arithmetic, unfamiliarity with the science fields may make them hesitate to apply it in that area. Yet science problems are such a natural part of every child's world that the questions he asks are the easiest approach to the development of these particular skills and habits. Since educators agree pretty uniformly that our major objectives lie in the areas of appreciations, attitudes, skills, and habits rather than in subject matter as such, the training of children in the problem-solving method seems very important.

The first thing that a teacher must do before starting to help children learn problem solving is to be able to recognize good problem situations and good problems. Among the questions that children ask are many that are of passing interest and may be answered quickly and easily. But often some of these questions offer opportunities for real problem solving.

For example, a group of first-graders, during their science meeting were reporting their observations of natural happenings. Some of the questions about an icicle that one child showed were:

1. Can you see through that ice?
2. Why is the ice frozen around the stick?
3. Would it freeze again if we put it out today? (The icicle was melting.)
4. How was the icicle made?

The teacher recognized number four as a good problem to help the children start developing some skills, so she used it. The other questions were used in developing the problem.

Some of the things to keep in mind when selecting a problem from children's questions are:

1. Is it suitable for the age level of the child who is trying to solve it?

2. Is it worth spending time on?
3. Are the materials available with which to solve it?
4. Does it offer opportunities for many child activities?
5. Are the children interested in it?
6. Can it be solved within the interest span of the group?
7. Does it contain the elements that make it a real problem to the children?

To illustrate these criteria let us test the problem, "How was that icicle made?"

With a group of children who had had no previous experiences with ice, the problem might have been too difficult. To know this a teacher needs to analyze the problem for the concepts necessary to its understanding. Some of these concepts in this case are:

1. Ice is frozen water.
2. Water freezes out of doors in winter.
3. Heat melts ice.
4. Sunlight gives heat.
5. Snow is frozen water.

The first grade which asked the question about the icicles had developed these concepts in the kindergarten, so this problem was suitable for their group. The problem might have been just as suitable for a fifth or sixth grade which had not had the science experiences of this first grade.

Testing the problem by the second criterion, "Is it worth spending the time on it?" one might say that it isn't very important to know how icicles are formed. Certainly many adults are leading happy, useful lives without the knowledge. We can't justify the value of the problem by the knowledge objective.

From the standpoint of appreciation, icicles are beautiful. That is one reason they attract children. Icicles are also interesting and arouse curiosity. Curiosity, if properly directed, leads to the scientific attitude of sensitive curiosity. Besides these values, the fact that the children are trying to find an answer to their own question makes it an ideal way to develop problem-solving skills.

The third criterion, "Are there materials available with which to solve it?" is satisfied, since in winter we have temperatures for simple experiments with freezing. The fourth criterion, "Does it

offer opportunities for child activities?" is met in that all of the experiments, demonstrations, and observations needed for solution are easily done by six-year-olds. It satisfies number five, "Are the children interested in it?" because the children initiated the problem.

Criterion number six, "Can it be solved within the interest span of the group?" is satisfied at whatever age level we are solving the problem. In the first grade which raised this problem the interest span was rather short. The group met with the science teacher only once a week for a twenty-minute period. Yet for two or three weeks the children kept bringing icicles of different sizes and shapes to the science room, commenting upon them in such a way as to demonstrate an understanding and an appreciation of their formation. Of course their understanding was not as complete as that an older group would have, but as far as it went it was correct.

To check with criterion number seven, "Does it contain the elements of a real problem?" we must analyze what we mean by the elements of a good problem. Why is "How was that icicle made?" a good problem while "Can you see through the ice?" isn't so good?

In the first place, a problem must present an obstacle in thinking. "Can you see through the ice?" presents very little difficulty because to answer it the child merely holds the ice up and tries to look through it. There is no need for the problem-solving technique. The other question cannot be answered so readily. Unless the children have already met the question before and had it answered, they must discuss it and give possible answers based on their previous experiences. Then they must test these possible answers in various ways, finally drawing conclusions from the results of their data. True, this will be done very simply in the first grade, but by repeated learning situations of this kind even six-year-olds begin to develop these skills and habits.

Elementary teachers often say, "It is all very well for a science teacher to talk about these methods of teaching science to children, but theory and practice are two different things. *We* have to teach the children." Elementary teachers are justified in this criticism. Too often college teachers have a tendency to deal with

ideas and theory, neglecting contact with practical teaching situations.

For that reason let us examine several actual problem-solving lessons as taught at different grade levels, for the teaching skills needed to teach them.

The first one was taught in a first grade, and used only the materials of the environment. The problem was child-initiated when there was a hard rain and the children found earthworms on the sidewalk.

PROBLEM: Why do earthworms come out of the ground when it rains?

ANALYSIS:

Teacher's questions—

1. Where do earthworms usually live?
2. What must live things have in order to live?
3. What ideas do you have about why you found the earthworms on the sidewalks?

Hypotheses or possible answers given by the children were—

1. Maybe the earthworms want water.
2. Maybe the earthworms come out to breathe.
3. Maybe there is too much water in the ground so the earthworms will drown if they don't come out.
4. Maybe the earthworms' homes are ruined by rain and they have to come out.

SOLUTION:

A. Gathering data:

The teacher asked the children to suggest ways of finding out whether or not their answers were correct. As a result of the discussion, the children did these activities.

1. They put some earthworms on top of some soil and watched them burrow into the ground.
2. They examined some soil with a hand lens to see the spaces between the soil particles.

3. They put soil in water and saw bubbles of air escaping.
4. They poured water into a glass jar of soil until all of the air had bubbled out of the soil and water was standing on the soil.
5. They found earthworms in puddles where they had been unable to find drier soil.
6. They put water into the jar containing the earthworms and watched the earthworms.
7. The teacher drew an enlarged diagram of an earthworm's burrow to illustrate the relative sizes of worms to soil particles and air spaces.

B. Results:

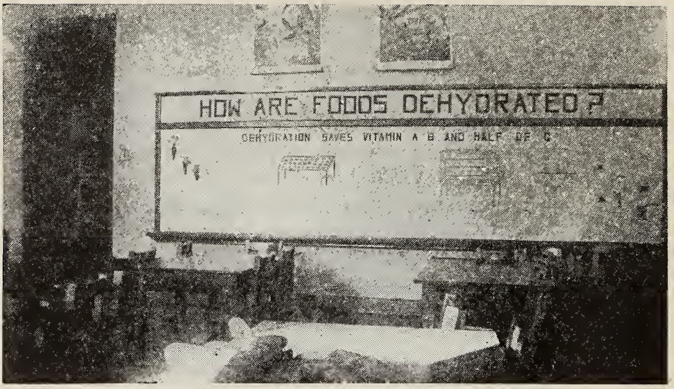
1. The earthworms burrowed into the moist soil, head end first.
2. The soil particles looked like tiny rocks.
3. & 4. Bubbles of air were plainly seen.
5. The earthworms in the puddles were dead.
6. As the water filled up the spaces between soil particles and air came out, the earthworms came to the surface and crawled out of the jar.

Conclusions:

When the earthworm's hole was full of water, it couldn't get air so it crawled out. When the ground was dry it would crawl back into its hole. If the earthworm couldn't get back into its hole and the ground was covered with water, it died.

This was a very simple problem but it offered all of the elements of real problem solving on a six-year-old level. The information could be gathered by the children themselves and was concrete enough for them to draw correct conclusions. They could check their results with those of the children in the story of earthworms in Through the Year.

This problem-solving lesson has illustrated the utilization by the teacher of a child's question for accomplishing her own objectives. We cannot always wait for questions to arise naturally to



As children grow older, their problems enlarge.

initiate science problems. The teacher must know the problems that are suitable for the group she is teaching, and at times she must create situations to motivate the setting up of these problems. Once initiated, the science program will usually keep going under its own power. New problems will grow out of those in the process of solution. The teacher and children will find themselves with more problems than they can possibly solve in the time they have. These problems should be recorded and used to start another year's work, or handled through individual or group reports.

As children grow older and develop more skill in handling problems, their problems will enlarge. They may break down these larger problems into minor problems to be solved. The time taken for solution will increase and the children may be taught to recognize the steps in their thinking. They may begin to record their data. This will be a group activity at first, with the teacher writing on the board the simple statements made by the children.

For example, a second grade in trying to answer their questions of "How did this piece of salt get on the shore of Salt Lake?" did some simple activities to clarify the concepts of *solution* and *evaporation.* At the end of one activity the teacher wrote the following results on the board as the children gave them to her.

1. Salt dissolves in water.

2. We couldn't see the salt in the water.
3. When the water evaporated we saw the salt again.

These children were able to check the results of this activity by reading in their second grade science text, WINTER COMES AND GOES.

Third-graders have developed enough reading skill to be able to supplement their own observations and experimentation by reading. They are also able to begin writing a few sentences as a record of the conclusions to their problems. The teacher should handle this just as she does the written language work the children do, being sure that the conclusions recorded are correct.

Analyzing problem solving for some of the difficulties that arise in teaching it, let us look at a rather simple lesson, "Why does a candle burn?" What are the concepts and skills a child needs for setting up the hypothesis and solving it? Some of the concepts needed are:

1. A candle is made of wax.
2. Wax is a solid.
3. Wax melts when heated.
4. Solids may be changed to liquids by heating.
5. Liquids may be changed to gases by further heating.
6. There is something in all fuels that burns.

Some of the skills the child will need are:

1. Ability to handle the simple apparatus needed.
2. Ability to observe accurately.
3. Ability to work carefully.
4. Ability to draw correct conclusions from accurately observed results.
5. Reading and language skills necessary for checking his results and recording them.

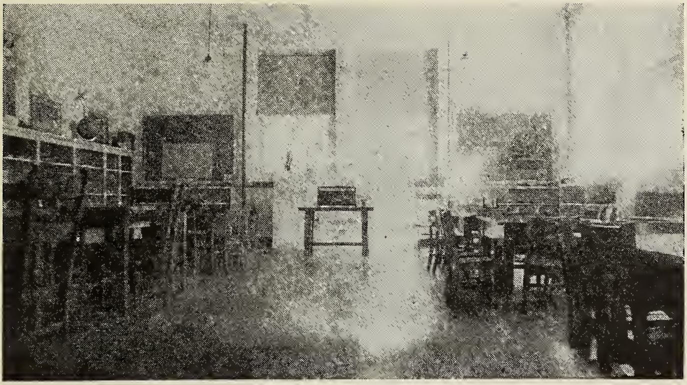
The teacher has to anticipate all of these needs and plan carefully. She must realize the safety measures to be provided in any experiment involving fire. She must guard against unscientific attitudes, such as drawing conclusions with insufficient evidence. She must be alert at every step in the procedure for opportunities to develop scientific attitudes and good habits of thinking.

Perhaps this all seems like a very complicated and difficult task to the teachers who have not used the problem-solving method. It would be if you started out trying to teach it all at once. If you begin slowly, one step at a time, you will find the children co-operating eagerly. The satisfaction gained by feeling that you are teaching habits of thinking that the children will be using long after they've forgotten some of the bits of information makes the effort worth while. A child's spontaneous comment at the end of the solution of the problem, "Why do teeth decay?" illustrates this point. It had taken some time to finish and the teacher was feeling a bit discouraged at the seeming waste of time. The child wrote his last sentence of the conclusion with an audible sigh of satisfaction and remarked, "Boy! I call that finishing a real job. That's really getting something when you find out yourself instead of just reading." When the children themselves realize the value of their learning, it must be worth while.

These values, in part, are:

1. The ability to recognize and formulate problems.
2. The ability to set up reasonable hypotheses.
3. The ability to gather data by means of suitable activities for testing the hypotheses.
4. The ability to record accurate results.
5. The ability to generalize from results, draw correct conclusions, and check with an authority.
6. The ability to apply the conclusions to similar problems.

In addition to these skills and habits, scientific attitudes and knowledge are gained in the solution of pertinent problems.

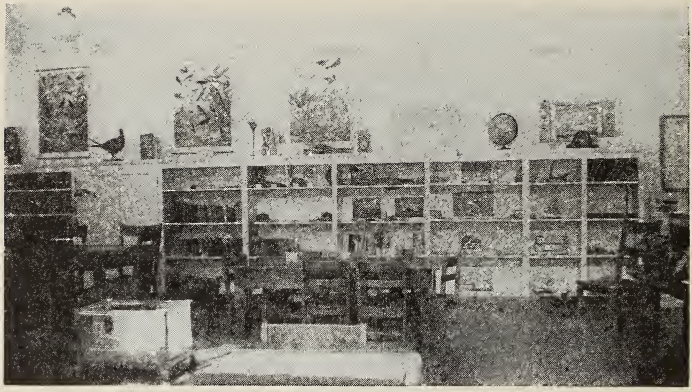


A science room.

SCIENCE ACTIVITIES COMMON TO ALL GRADES

THE SCIENCE ROOM

The problem of how to care for materials and specimens is a real one for the grade teacher. If there is a separate science room, these may be cared for in the cabinets, display cases, and closets provided for them. If not, some space must be allotted in the regular classroom. They need not take up much room, for the apparatus needed for teaching elementary science is simple. A few glass jars, dishes and bottles, a few tin cans, some pieces of wire netting, cheesecloth and some candles may be the only things needed. An electric plate, alcohol lamp, or some other source of heat is necessary for some of the experiments suggested. But if these are not available, other common experiences may be substituted. In some schools it is against the rules to have fire in the classroom. Unless an electric plate can be obtained, the radiator is the only source of heat. There is such a variety of home-made equipment and substitutes for expensive apparatus that the ingenious teacher can always find some material for her activities. Running water is a great convenience. The children should have



Shelves provide places for permanent collections.

a share in assembling needed apparatus but the teacher must be responsible for seeing that it is ready when it is needed.

The regular classroom may be made more attractive with a few well-kept aquaria, terraria, and growing plants. Suggestions for maintaining these in good condition are given in other parts of this Manual. A science table will provide for the specimens of rocks, insects, birds' nests, and other things the children collect and bring to school. It should be well kept and cleared at intervals. As a child brings in his contribution it can be discussed, named, and put on the table with a small sign telling what it is and the name of the donor. A few cases of shelves will provide a place for more permanent collections.

A table with a few interesting things that the teacher provides helps to stimulate science work. These specimens should have labels telling enough about them to arouse curiosity and a desire to know more. For example, an oyster shell may be labeled, "This is the outside of an animal. It lived in the sea. It is used for food. You have a relative of this *oyster* in your aquarium. Do you know what it is?" The relative is a snail or perhaps a clam.

In some schools, glass display cases in the hall offer a place where science material may be exhibited. These exhibits should be changed frequently. For example, a group of children may

be studying rocks. They may put some of their best specimens, with neat labels, in the hall case. Other children of the school will enjoy this display and learn from it.

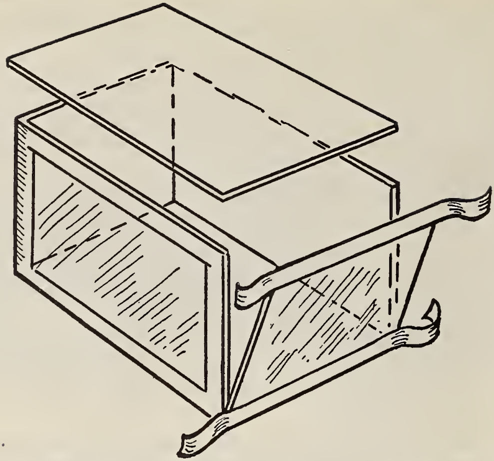
If the teacher wishes to buy equipment she may order it from any one of several scientific supply companies. Many of the things she needs such as dry cells, wire, and magnets may be bought at local ten-cent stores.

Bulletin boards are an important addition to the science room. They may be used by the children for the clippings and pictures they bring to class. The teacher may use them to motivate units or lessons, or to display summarizing activities at the end of a unit. They may be used for pictures of birds, wild flowers, or other aids to identification. There are many charts, such as the Audubon Bird Charts, which may be used for the same purpose. Bookshelves for reference books and magazines and a case for maps and charts should be provided.

Science material, whether it is alive, or is physical apparatus, must be kept in good condition. Nothing is so likely to kill the interest in science as dirty glassware standing around the room, cloudy aquariums, boxes of dead caterpillars, or unhealthy animals. There is much plain housekeeping in the science room, but all of it can be used to help teach children careful habits, particularly if the children are given the responsibility of helping to do this housekeeping.

HOW TO MAKE A TERRARIUM

A simple terrarium has so many uses that it is well to know how to make one. First, it is necessary to have a container. A glass jar of any kind will do, but one with straight sides is better than a round one. A glass box may be easily made from six pieces of window glass cut to the desired size. These may be fastened together with one-inch adhesive tape or black *passe partout* tape. Rub the tape until it sticks firmly to the glass. The lid may be fastened so that it is hinged, or merely laid across the top. All edges should be bound with tape to prevent cut fingers. A further precaution is to have the edges of the glass beveled at the time it is being cut.



A terrarium made from glass and adhesive tape.

A wooden base instead of a glass one may be used for the box. If wood is used, it should be so cut that at least one inch will project from around the glass at the bottom. The board may be treated with melted paraffin to make it resistant to water. A half-inch furrow should be sawed in the wooden base, the dimensions of the glass, and made wide enough to take the glass. The glass sides can be more firmly secured in the furrow by means of aquarium cement or putty. Adhesive tape may be put around the top to make smooth edges.

Having a container, start making the terrarium by putting a layer of gravel in the bottom, to provide drainage. Small pieces of charcoal will help keep it sweet. On top of the gravel put soil of the kind found where the plants grow which are to be used in the terrarium. For example, moss and ferns come from the woods. Use woods soil, or leaf mold, for a woods terrarium. Use garden loam for a garden terrarium. Use sand for a desert terrarium.

In the soil plant the moss, ferns, or other plants you wish to use. If you are going to put animals which eat plants into the terrarium, some of these food plants should be planted. For example, if

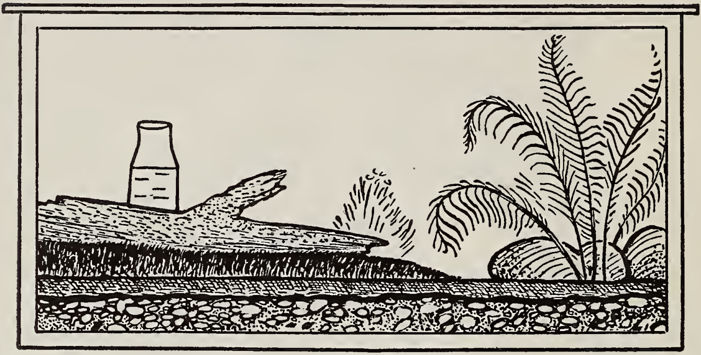
Making a terrarium for a garter snake.

making a home for grasshoppers, plant corn or oats and let it sprout before putting in the insects. For toads, use garden soil, a dish of water sunk into it, with perhaps some stones and a little grass. The toad will bury itself in the soil. Salamanders like moist moss and pieces of decaying wood under which to bury themselves. Lizards and horned toads will bury themselves in the sand of a desert terrarium.

The terrarium should be kept out of strong sunlight and in a place that is not too warm. It should be sprinkled with water when first made, if it has plants in it. After that it should be sprinkled only when the cover gets dry on the underside. Water should be kept in a dish if there are animals in the terrarium. Snakes go into water, and a tall container like a pint milk bottle or pickle jar of water will make them comfortable. A low dish is better for turtles and toads. This can be placed in one end of the

terrarium and stones and soil built up around it to the level of the top of the dish.

A single terrarium should not contain a large variety of animals. Since boxes of glass and adhesive tape are practical and inexpensive, it is better to have several, each one containing a different kind of animal.



A woods terrarium.

The food of frogs and toads in the wild state consists of insects, worms, caterpillars, snails, and slugs. They also eat flies, mosquitoes, and gnats. These can be easily provided, but they should always be alive. Frogs and toads will not touch dead worms or insects. They will starve in a terrarium if they have no live food to eat. A fly trap can be made and once a day the flies released from the trap into the terrarium. When there are insects out of doors, they may be caught by sweeping the grass with an insect net. In winter when flies are scarce, meal worms and meal bugs, which can be cultivated in bran flour, can be substituted.

Newts and salamanders can be fed on bits of raw meat, fish, oysters, scrambled eggs, worms, or insects. Land turtles are plant-eaters, using tender plants and berries for food. Water turtles are meat-eaters, using earthworms, insects, crayfish, and small fish. Mud turtles do not eat unless they are under water. Horned toads eat living insects. Garter snakes eat earthworms, insects, frogs,

salamanders, and toads. Snails are vegetarians; lettuce is a good food for them.

Care should be taken that an excess of uneaten food does not remain in a terrarium. Terrariums should be kept clean so that the captive animals may live in healthful conditions.

HOW TO MAKE AN AQUARIUM

Almost any container that holds water may be used for an aquarium, but a straight-sided one is best. The globe-shaped ones afford too little water surface for the absorption of air and they distort the shape of objects inside the aquarium.

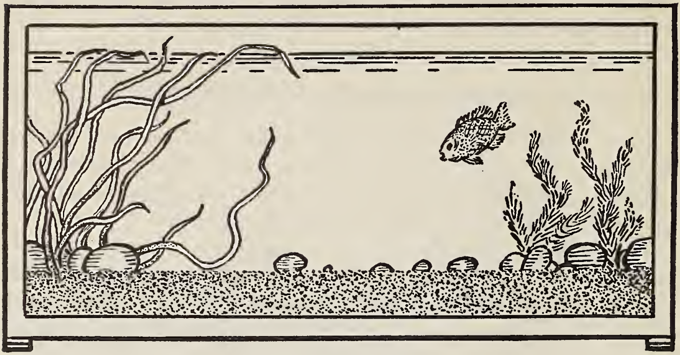
The container must be very clean, and the sand must be thoroughly washed. Sand may be washed by running a stream of water into the pan of sand until the water runs out clean. If the sand is then baked in an oven, any bacteria or mold spores will be killed.

Enough sand should be put into the bottom of the aquarium to insure a good root-hold for the plants. Elodea, eelgrass, and water milfoil are all good aquarium plants and are common in most of our fresh-water lakes and streams. These are satisfactory for summer aquariums but they do not always survive the winter. There are many inexpensive tropical water plants which can be used. Such varieties as Valisneria, Cobomba, Myophilum, and Sagittarium are commonly obtainable. It is believed that Valisneria is the best oxygenating plant. This is a grasslike plant which grows very quickly. Duckweed is a small leaflife plant that is often found floating on ponds. It is attractive in an aquarium, though it doesn't help to supply much oxygen.

The plants should be planted in the sand, then anchored with stones. Water can be poured into the aquarium without disturbing the plants by putting a piece of paper on the sand and pouring the water on the paper, or a dish may be placed on the sand into which the water can be poured.

Clean pond, lake, or rain water is best for an aquarium because it contains minute organisms that may later feed the animals. If tap water must be used, allow it to stand several days before putting it into the aquarium. This allows any lime that might spoil

the sides of the aquarium to be deposited and frees the water from any chlorine that has been added for purification. After adding the water, allow the plants time to become rooted before putting



A simple aquarium.

in the fish or tadpoles. Otherwise the animals may pull up the plants.

One rule for the number of fish in an aquarium is one three-inch fish to a gallon of water. Another rule is an inch of fish for each 20 square inches of water surface at the top. Most people are inclined to put more fish into an aquarium than the amount of water justifies.

Any kind of aquarium fish such as goldfish or tropical fish may be put into an aquarium. However, tropical fish are more difficult to keep than goldfish, and require more attention. The water temperature must be kept above 65° for tropicals, and the feeding must be more regular.

Of the tropical fish, guppies, swordtails, and paradise fish survive well and they have interesting habits. Guppies and swordtails are livebearers. Under favorable conditions, guppies reproduce every six weeks. The bubble-nests of the paradise fish are interesting. Tropical fish and goldfish should not be put together in an aquarium as tropical fish often kill the goldfish. Also the fighting paradise fish must be kept away from other tropical fish.

Some wild fish will survive in an aquarium and they make in-

teresting pets. Small sunfish, bluegills, and bullheads are examples.

Snails should be put into the aquarium to act as scavengers. They help keep the sides of the aquarium clean. Tadpoles will serve the same purpose. Clams also help keep the water clean. If water turtles and small frogs are put into an aquarium, they should be provided with flat pieces of wood onto which they can crawl and get out of the water for air.

The first rule in the feeding of fish is not to overfeed. Only a small amount of food should be given, or as much as will be consumed at that feeding. Food not eaten at once falls to the bottom of the container, sours, and makes the water impure. Goldfish can be fed as seldom as once a week. They should not be fed more than three times a week. Tropical fish should be fed three times weekly.

Oatmeal (cooked), boiled white of egg, cream of wheat (cooked), liver (cooked), beef (cooked or raw), chopped earthworms, and flies are good food for both goldfish and tropicals. These foods are better than artificial food. If wild fish are used, the children should find out about the natural food of these fish and supply it as nearly as possible. Wild fish can usually be fed on earthworms and chopped raw beef. They will also eat live insects placed on the surface of the water.

If the aquarium is balanced, the animals and plants will look healthy and the water will be clear. Cloudy or milky water is probably due to the spoiling of uneaten food, or to decaying plants. This water is bad for fish. Immediately remove the fish and clean the aquarium and replenish with fresh water. In changing fish from one container to another, keep water temperatures the same. Fish cannot stand sudden changes of temperature. Be sure also that tap water has been properly conditioned to remove chlorine.

Fish should be handled with a small net or lifted out in a dish of water. Grasping them with the hands is likely to break the film over the scales and permit fungus to get started. If a fish is diseased, remove it at once and put it into a solution of salt water, in proportions of one teaspoon of salt to a quart of water. It may remain in the solution for a period of several hours. Then put it

into a container of fresh water. Repeat the treatment every day until the fish is well.

The children will get much pleasure and profit from their management of both terraria and aquaria. There are many interesting aquarium books and magazines on the market to which they can turn for lists of animals and plants and for notes on feeding. Also in recent years there has been much interest in amateur tropical fish raising and many of the children may come from homes where there is a tropical fish enthusiast.

HOW TO CARE FOR CATERPILLARS

Some caterpillars spin cocoons, some form chrysalids, some go into the ground to pupate, some spend the winter hibernating in the larval stage. In discussing them with the children, suggest that since the caterpillars they find may not be ready to pupate, they must be sure to bring in some of the leaves on which they find the larvae. Then you will know what to feed them. Caterpillars will leave food and hunt a suitable place when they are ready to pupate. Polyphemus caterpillars may be put into a glass jar that has some twigs with leaves on them. A piece of glass may be laid over the top of the jar. This prevents escape of the caterpillar and also helps keep the leaves fresh. If the caterpillar is still hungry it will eat the leaves. The jar should be cleaned each day and fresh leaves put into it. When the caterpillar is ready to spin, it will use the twigs and sides of the jar as its foundation and spin leaves into its cocoon. When the cocoon is finished, it may be removed from the jar and put into a cool place until spring. Jar and all may be put away. If it is kept in a dry place, the cocoon should be dipped in water once in a while.

Caterpillars like the tomato sphinx (tomato worm) go into the ground to pupate. There should be some garden soil in the bottom of the jar for them. A flower pot with a cylinder of wire screening over it is good, also. Some Woolly Bears hibernate in the larval stage so a terrarium with some dead leaves and pieces of bark makes a good home for them. They will spin in the spring. Some Woolly Bears spin in the autumn.

The Monarch or milkweed caterpillar forms a chrysalis. If the children bring any Monarch caterpillars in, put them into a jar

with milkweed leaves. When ready to pupate, they will spin pads of silk on the underside of a jar lid, leaf, or twig, then hang from it and shed the larva skin, leaving the green chrysalis. Since the caterpillars that form chrysalids in the autumn soon emerge, they may be left in the room for the children to watch. Chrysalids of butterflies that emerge in the spring may be cared for in the same way as the cocoons.

Fruit and salad dressing jars are just as good as more elaborate equipment. The main things to keep in mind are to have fresh leaves of the right kind which are kept from drying too quickly but are not wet, and not to have too much heat. After pupae are formed, they should be placed in a cool place, not moist enough to mold, but not dry enough to kill the pupae. Cleanliness in their care is important, as many caterpillars are susceptible to disease. Also when handling caterpillars, be careful not to bruise them. It is better to let them crawl onto a twig and then move the twig, than to pick them up with your hands.

OTHER ANIMALS IN THE SCIENCE ROOM

The extent to which it may be desirable to keep animals in a schoolroom depends upon the size and facilities of the room, the interests of the children, and the kinds of animals you wish to keep. While some plants and animals if properly cared for are sure to make a room more interesting, we mustn't lost sight of the fact that the children are the most important occupants of the room. If having other animals makes the room less attractive or comfortable for the children, you should either do without the other animals, or choose animals that are easily kept in captivity and cared for.

Directions for the care of aquarium and terrarium animals have already been given. All these cold-blooded animals are clean in their habits and have little or no odor about them.

Small mammals such as rats, mice, guinea pigs, and rabbits may be kept in cages in the room if the cages are kept clean. Cages with removable metal bottoms are more easily cleaned than wooden ones. A cage may be made of an orange crate with a galvanized iron tray made to slide in the bottom of the box. One-

Observing a turtle.

half-inch mesh galvanized wire should be fastened to the open side and a sheltered corner should be made of a smaller box which is placed inside the cage. All animals need to have a place in which to hide.

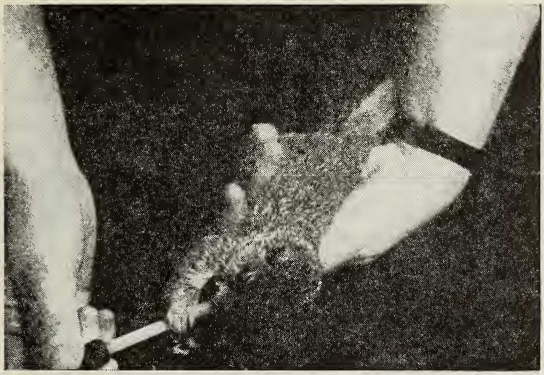
Sawdust or straw should cover the floor of the cage and be replaced with fresh material every day. If a layer of newspaper is put on the floor first, the cage can be more easily cleaned. The animal will carry some of the nesting material into its sheltered corner for a bed.

Guinea pigs and white rats are more easily kept in a schoolroom than rabbits. Rabbits may be brought in for a day or two, but it is better for them to live out of doors.

These rodents may be fed oats, alfalfa hay, carrots, and other vegetables. The young ones should have milk and a few drops of cod liver oil each day during the time when they do not get plenty of sunshine.

If the schoolroom is closed and becomes either very hot or cold over the week-ends, the animals should be taken to the home of one of the children. Extremes of temperature are not good for warm-blooded animals, particularly when in captivity where they can't protect themselves.

Although many of these animals are able to get their water from



Feeding a young squirrel.

their food, water should always be provided in the cages. The container should be low enough for the animal to drink from and of a kind not easily tipped over.

Wild rodents, such as meadow mice, squirrels, and chipmunks are sometimes brought into the schoolroom. Adult wild animals are difficult to tame and often refuse to eat. Young wild rodents, however, may be cared for and make interesting pets. If they are very young they may be fed on warm, diluted condensed milk. The smaller the animal the more warm water should be added to the milk, the more frequently it should be fed, and the less it should have at each feeding. One needs to use common sense in caring for these young animals. Keep them warm, let them alone as much as possible, and don't overfeed them.

Children sometimes bring other young mammals to school. Until the animal is old enough to eat solid food, its care is the same as for the other animals mentioned above. Teachers may find detailed directions for rearing all kinds of wild animals in Moore's *Wild Pets*. See reference list.

Young birds are easily reared if you know the food to give them. Any good bird book will tell the food of the common species of birds. Insect-eating birds may be fed earthworms, caterpillars, and small larvae of beetles. Hard-boiled eggs may be substituted

for part of their food. The shells should be crushed and fed with the egg. Young flickers may be fed on raw eggs and ants.

Seed-eating birds may be fed any kind of small seeds. Chick-feed is easily obtained. Some bread may be given them but should be supplemented with seeds. All birds need sand and other hard foods.

When a bird is first found it may have to be fed forcibly. Open its beak gently and put the food in the back of its throat. A pair of forceps or tweezers is useful in accomplishing this. The bird won't swallow unless the food touches the swallowing center on the back of its tongue.

Fish-eating birds such as bitterns and loons are occasionally found and brought to school. These are problems to feed as they do not thrive on dead fish. The author has successfully fed young fish-eating birds on live tadpoles and minnows.

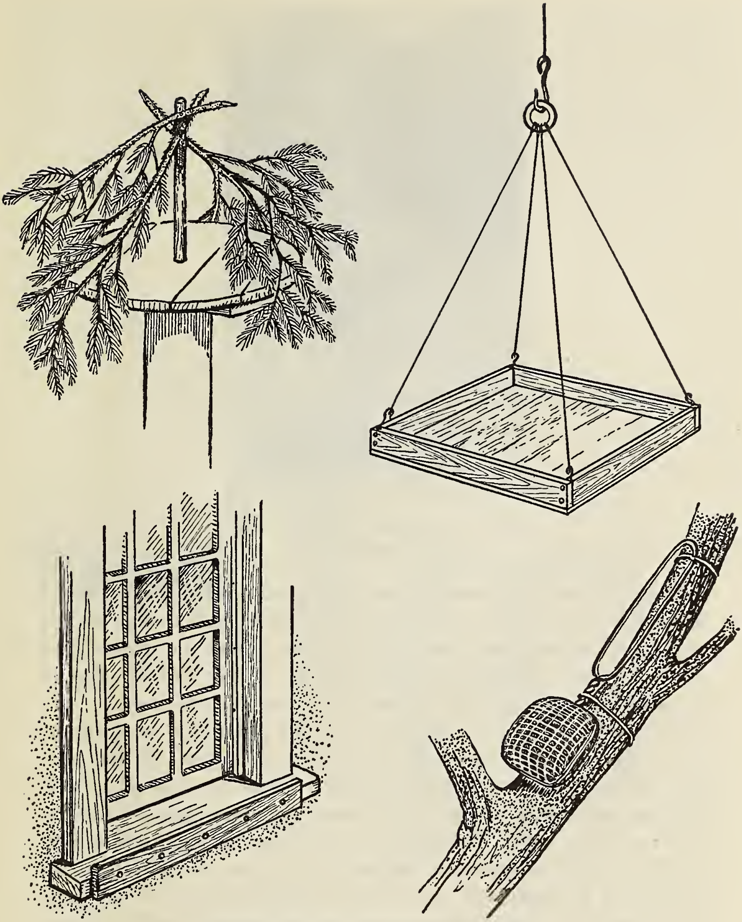
Hawks and owls may be fed pieces of meat which have been wrapped in cotton or rolled in sand. These birds should be handled with care as their bite is painful. Young ones soon learn where their food is coming from and open their mouths.

Unless a wild animal is too young to care for itself, it is wise to keep it awhile for study and then release it. School buildings are not built to house the lower animals. A trip to a well-run zoo will demonstrate how varied are the needs of the different groups of animals. It would be impossible to duplicate these conditions in a room where children live. A cage built outside a window on a level with the window sill will partially solve the problem. If a squirrel or rabbit is to be kept for any length of time this might be worth while.

In caring for any animal, the children should be made to feel responsible. They should read about the natural habitat and food of the animal and try as nearly as possible to duplicate these conditions. Even though some animals die, the value to the children makes caring for them worth while.

WINTER BIRD FEEDING

In the northern part of the United States most of the common birds migrate in the autumn but there are a few that remain through the winter. Why birds migrate is a question no one has



Simple feeding stations for birds.

solved satisfactorily, although there has been much written on the subject. The teacher should familiarize herself with the theories of migration and not try to solve the problem.

Half a coconut may be filled with melted fat.

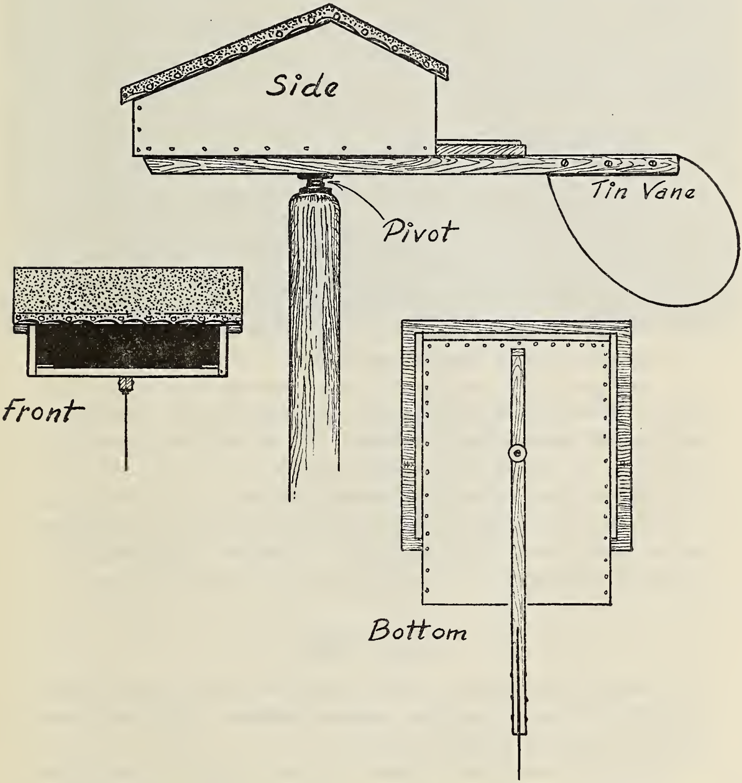
Some winter bird residents stay the year around in the north. Among these are the chickadees, nuthatches, and downy woodpeckers. Others come from farther north, spend the winter, and return to their northern nesting grounds in the spring. Brown creepers, juncoes, and tree sparrows are examples of these.

Some winter birds are insect-eaters and some feed on seeds or fruit. The downy woodpecker is able to chisel through the bark of a tree and with its tongue spear the larvae underneath. Nuthatches and brown creepers get insect eggs and insects from the crevices in the bark. Chickadees and titmice find their insect food mostly in the buds and on the twigs of shrubs or trees. But in winter, all of these will eat whatever they can find. Since they are meat-eaters, we put suet or nuts on the feeding shelf for them. To prevent suet from being carried away by a blue jay or starling, it may be put into a wire basket made of coarse screening.

A soap shaker may be filled with suet and hung from a wire. The suet may be tacked to a tree or tied to a limb. The nuts

should be crushed or finely cracked to prevent squirrels from carrying them away. Birds will scratch among the shells and pick up the bits of nut meats. Walnuts or hickory nuts are good bird food, and may be gathered by the children in the autumn, to save for winter feeding. Half a coconut may be filled with melted fat and hung from a branch. Cracked nuts or seeds may be added to the fat.

Juncoes, sparrows, goldfinches, and cardinals are seed-eaters.



A more elaborate feeding station.

Any seeds, such as wheat, oats, millet, or cracked corn, will attract them. Sweepings from a mill are welcomed by birds and they will scratch in the chaff for days, finding tidbits. Cardinals and grosbeaks are especially fond of sunflower seeds. Crumbs of any kind will attract birds, as will berries and pieces of other fruits. The children can put out discarded apple cores and cranberries. Breakfast food or other cereals which might be discarded because of weevils are good bird food. Even weed seeds are attractive to birds.

Shrubs with berries on them always attract birds. Among these are snowberry, barberry, high-bush cranberry, wild plum or cherry, and bush honeysuckle. Teachers who have anything to do with landscaping the school grounds should see that some such shrubs are planted.

A simple shelf is as effective as a more elaborate one. Just an extension from the window will work, although a roof prevents snow from covering the food. The birds may not come at first, so a good way to get them started is to sprinkle some grain on the ground under the shelf. The sparrows will come first and though we do not care so much for them, they show the other birds the way. A dry doughnut dangling at the end of a string will provide entertainment equal to circus acrobats.

A swinging shelf usually frightens sparrows and drives them away. However, for teaching purposes in the primary grades even an English sparrow has possibilities. It is surprising how many adults do not really know English sparrows.

In snowy, freezing weather, water is as hard for birds to get as is food, so water should be put out for them each day. It will often attract birds not attracted by food. A shallow earthenware container like the saucer of a flower pot is good for this purpose.

FIELD TRIPS

If properly conducted, a field trip may be an important activity to help in the solving of some science problem. Improperly conducted, it may be a waste of time.

A field trip must have purpose. It must come as a result of a need to learn something outside the schoolroom. It need not mean

A field trip—looking for birds' nests.

a long trip. For example, in a discussion of soil formation the question may arise of whether freezing and thawing break up rock and form soil. To illustrate this, the children may go outdoors and find rocks that have been cracked in this way. Even sidewalks and the foundations of buildings illustrate the point.

The teacher should anticipate any trip she plans and make the trip herself before she takes the children. If she intends taking the children to see birds, she should make sure that there will be birds to see. Birds are elusive and cannot be tagged and made to stay in one place. But a nest that is being built, or the work of a woodpecker located by the teacher or some member of the class, will remain until the whole class sees it. With a definite objective in mind, the teacher is sure to prevent disappointment and aimless looking.

Before starting on a trip, the teacher must be sure that every

A field trip—locating territories of birds.

child knows what he is going to look for. There is endless variety in the number of interesting things to see out of doors, but unless the attention is directed to a few, there will be confusion, and no learning will result.

For example, on the way to a river to see erosion, the group may watch for terraces that have been made as the river cut down to its present bed.

A large group should be organized into small units with a leader for each. These may be working on the same problem or different problems. If unusual things are found, the whole group may be called together to see them.

A simple way to organize groups is to make enough slips of paper for each member of the class. Number them from one to five. Circle one one, one two, one three, one four, and one five.

After a field trip—rock study.

Have the children draw slips. All the ones make a group. All the twos make a group, and so on. The children with the circled numbers are the leaders for the day.

Children like to make their own rules for field trips and take pride in following them. Here is a set of rules made by a third-grade class before going on a trip to study birds.

1. Walk quietly. No loud talking.
2. Follow your leader.
3. When you see a bird, stop. When the leader stops, everyone stops.
4. When you see a bird and want to show it to the rest of the group, tell them where it is without pointing. (Birds see better than they hear and are startled by quick motions.)
5. When you are looking at a bird, stand with your back to the sun.

Too many rules are confusing just as too many directions are. It is better to take short trips at first, trying out one rule; then add more rules as longer trips are taken. If the children understand what the trips are for, they will gain the proper attitudes toward them.

It is very important in any science work to respect the discoveries and ideas of children. When they see or find things on a trip, the group should give as serious attention to them as to the teacher's contributions. This encourages children to observe and it intensifies their interest.

On a collecting trip, enough containers should be taken along to carry back any specimens. Directions on how to collect and what to collect should be clearly understood before leaving the school. Collecting should be done only when material collected is to be used. If such material may be studied to better advantage in the schoolroom than out of doors, it serves a purpose. But only as much as is needed should be taken. Gathering hundreds of frogs' eggs would be wasteful when a few would be all the children could care for. It is better to raise a few tadpoles to adulthood than to have dozens die for lack of room or food.

Some of the types of trips may be listed as follows:

1. A trip to locate territories of birds. Return at regular intervals to watch nest building and rearing of young.
2. A trip to collect rocks.
3. A trip to see types of erosion.
4. A trip to find tracks of animals.
5. A trip to find and collect galls.
6. A trip to a zoo or museum to see something that has been discussed in class, such as fossils.
7. A trip to a meadow to collect weed seeds.
8. A trip to observe the sky.

The suggestions for teachers in connection with the stories list other ways to give purpose and variety to field trips. Trips should never grow so common or become so regular as to be monotonous, nor so dull as to be meaningless. Children should always regard them with enthusiasm, not because they offer an opportunity for play, but because they are the most satisfying solution to many of their science problems.

THE HOW AND WHY SCIENCE BOOKS

BASIS FOR CHOICE OF MATERIAL

CHILDREN'S INTERESTS

Children's interests were closely studied in preparing and organizing the material used in THE HOW AND WHY SCIENCE BOOKS. The subject matter was used by the authors in actual teaching experiences over a period of several years and with many different age groups of children. The problems were used in mimeographed form until arranged for publication.

RECENT COURSES OF STUDY

The material for the books was originally chosen from units that appeared in many courses of study from many sections of the United States. City and state courses of study were consulted, as well as those prepared and used in teacher-training institutions. More recent studies, problems which have arisen in the classes of the authors, and new courses of study have added new material to the original series.

The outlines for science in the elementary grades found in the *Thirty-First Yearbook* and in the *Forty-Sixth Yearbook* of the National Society for the Study of Education have been closely followed. Some quotations from the *Forty-Sixth Yearbook* are of interest here:

"Instruction in science should begin as early as children enter school; activities involving science should be provided even in the pre-school and the kindergarten. Through the sixth grade the work in elementary science should consist of a continuous integrated program of the sort advocated by the *Thirty-First Yearbook*. Such a program should provide an expanding, spiral development of understandings, attitudes, and skills, as prescribed in chapter iii."—pp. 41–42

"It is most important that the material selected for each grade of the primary school be balanced to include the elements of learning which represent a rich experience with science. Each level should give the child some opportunity for exploration with content derived from the great major fields of science: astronomy, biology, geology, and physics. This cannot be accomplished by studying only plants and animals.

"There should also be balanced instruction as to the types of activities employed. Children should have a rich opportunity to develop their abilities in discussion, in experimentation, in observing in the out of doors, and in reading for information and motivation. A complete program of instruction in primary science can be maintained only by the full utilization of all these activities, for each plays its part in the development of the purposes of science education."—p. 84

"Since experimentation involves 'learning by doing,' there can be no substitute for it. Pupil experimentation is an essential part of science education. In every course of science offered at any level, therefore, opportunities should be provided for pupils to perform experiments." —p. 53

"The basic purpose of the elementary school is the development of desirable social behavior. Science, with its dynamic aspects, its insistence upon critical-mindedness and better understanding of the world, and its demand for intelligent planning, has a large contribution to make to the content and method of elementary education.

"To accomplish this basic purpose a continuous program of science instruction should be developed throughout public school education, based upon a recognition of the large ideas and basic principles of science and the elements of the scientific method. Children must be given opportunity to gain the knowledge necessary for intelligent and

cooperative experience with the world of matter, energy, and living things and to develop constructive appreciations, attitudes, and interests. This demands that the individuals in our society become intelligent with reference to the place of science in individual and social life.

"When the content and method of science are examined, it is found that the child's normal activities have much in common with the purposes of science in modern society and that the teacher can view the teaching of science as utilizing the natural dynamic drives and potentialities of children."—p. 73

"Work in the primary grades should not be exhaustive. Rather the child should feel that there is more to learn about everything that he does. A developmental point of view demands that a well-balanced program provide contacts with realities. It cannot allow omissions in the development of the concepts, principles, attitudes, appreciations, and interests derived from the field of science."—p. 82

"The new program of science, which emphasizes the development of desirable social behavior, is organized around problems that have social value and are challenging and worth while to children. The teacher must, therefore, look back of the objects of the universe to the problems which involve meanings that the children will need to understand in order to participate intelligently in life. This means that, in science, opportunities must be provided for the development of understandings in all the areas of the environment and at all levels of social needs."—p. 92

HEALTH, SAFETY, CONSERVATION, AND AERONAUTICS AS INTEGRAL PARTS OF A SCIENCE PROGRAM

The authors of The How and Why Science Series have made health, safety, conservation, and aeronautics integral parts of the science program. This is in accordance with the recommendations of the *Forty-Sixth Yearbook*:

"*What is the place in the science curriculum of conservation, aeronautics, physiology, and health education?* The materials of these areas are of value chiefly for general education. Except, perhaps, for an eighth-grade one-semester course in health and physiology, it is probably not desirable to offer separate courses in any of these subjects. Their materials can be more effectively integrated with those of the regular courses of the science sequence and with other courses in the program of studies."—p. 46

"The content of the science program in many elementary schools is now being organized around problems which have social value and which are significant in the lives of children. These problems arise from children's

interest in the world around them and from their need to meet intelligently their problems of living in areas such as health, conservation, and safety. They are solved not through the mere accumulation of facts but in such a way as to help children (1) develop meanings which are essential to social understanding, and (2) put into practice desirable social behavior. Problems involve meanings in their solution, and meanings are learned through experiences."—pp. 69–70

"A program in science should develop a large background for the teaching of health. Many schools are now integrating health entirely with science and the social studies. Science provides much of the background for the teaching of health facts and the development of health habits. Moreover, in their study of science, pupils should gain a vision of the potentialities of science in the improvement of the health of the nation and the world."—p. 76

"Likewise, science is involved in accident prevention and safety instruction. We cannot fully anticipate the environment of the future. New inventions may eliminate present hazards and create new ones, making it impossible to develop a code of conduct in safety instruction which will be functional for an entire life span. It may be well, then, in safety instruction to place more emphasis upon the scientific principles which are basic to safe conduct."—p. 77

"The place of science in bringing about the wise utilization of natural resources to the welfare of mankind is an important aspect of the science areas related to the social needs."—p. 77

Health lessons throughout The How and Why Science Books are not labeled as such but take their places naturally as a part of the science program. They are taught also by implication in the illustrations. If health concepts are included in a science book, children learn to assume a scientific attitude concerning health problems. Many science problems are also health problems. The use of the thermometer is taught in science, and it has many implications for health. The germ theories of disease, contagion, and quarantine are all science subjects that are important in health.

Safety is taught both in connection with health and as a part of scientific procedure.

Many activities in science may contribute to the goal of conservation education. Appreciation of the natural and physical world (one of the objectives of all science teaching) should lead

to conservation of wild life and other natural resources. Throughout the books of The How and Why Science Series are such stories as "We Need Soil," "Insect Catchers," "Plants Depend on Animals," "Animals Depend on Plants," "Use—Don't Waste." As in the case of the health and safety lessons, the conservation material takes its place naturally as a part of the science program.

Although World War II gave an added importance to the subject of aeronautics, and a considerable number of separate courses in this field are being taught, chiefly in the senior high school, the authors of The How and Why Science Series believe that this subject can be more effectively integrated with the regular science course. Beginning in the Pre-Primer, the books of the series provide valuable and adequate instruction about the science of flight. Again, this material takes its place as a part of the science program in the study of air and its properties.

THE PLAN OF THE PRIMARY SERIES

SCIENCE THROUGH STORIES AND PICTURES

The books of The How and Why Science Series have a wide scope, including the fields of natural science, physical science, and human science.

The plan of the primary books is to tell stories dealing with the interpretation of natural phenomena common to the experience of children. Science is just as exciting as any other body of subject matter if told in a way that appeals to children. However, the restricted vocabulary of the early grades is often a handicap in presenting what are really simple science concepts. Such concepts can be taught effectively by pictures. In fact, before children can read the words, they enjoy looking at the pictures, and may learn science concepts from them. The books of The How and Why Science Series are beautifully and effectively illustrated. The pictures are reproduced from original water-color paintings by a method so faithful in its reproduction that the illustrations in the books seem themselves to be original paintings.

Nowhere is there a better expression of what appeals to children in the way of books than in the opening chapter of *Alice in Wonderland*:

> "Alice was beginning to get very tired of sitting by her sister on the bank, and of having nothing to do. Once or twice she had peeped into the book her sister was reading, but it had no pictures or conversation in it, and 'What is the use of a book,' thought Alice, 'without pictures or conversation?' "

The books of THE HOW AND WHY SCIENCE SERIES have *pictures* and *conversation.* The pictures are accurate and beautiful. The conversation is natural and interesting.

THE ORGANIZATION OF MATERIAL

The early books of the series are organized seasonally although the units may be taught at any time. Biological units to be natural have to be seasonal.

Most scientific principles are too difficult for little children to understand. But they can understand concepts which may grow from year to year until finally they can be put together to make a principle. For example, the principle that living things have certain modifications of structure which make it possible for them to survive is too difficult for first-graders. But they can observe that animals are doing different things in autumn, winter, and spring. In the second grade they learn more about these animals such as ways in which they survive the winter by hibernating, pupating, and migrating. In the third grade they enlarge the idea to include ways these animals are protected so that they do survive, such as fur, scales, and feathers. Thus as children are able to comprehend larger concepts, they gain them. Eventually they will be able to derive the principle that animals have survived through the ages because of modifications in their bodies that make it possible for them to live in the environments in which they find themselves.

Because the authors believe in the problem-solving method of teaching, the material in the outlines is organized in the form of problems. If the teacher keeps these problems in mind as she teaches, purpose will be given to her work.

ILLUSTRATIVE MATERIAL

Environment and individual differences play such an important part in children's science interests that the teacher must be guided by her own group in the choice of problems. Some problems may have to be teacher-motivated because lack of experience on the

part of her group may mean that the children will not initiate them. Once introduced to the material, children should accept it with interest, otherwise it is not suitable for them.

The teacher who has had little science experience will find help in knowing what may interest her group from the suggestions given in this and other Manuals for the series, but *she should always be ready to follow child-initiated activities when they arise.* She should not be like the teacher who, having planned a lesson on buds, was disturbed when Johnny brought in a turtle. "Take it right back," she said. "Today we are studying buds."

Illustrative material should come primarily from the child's own environment, but not exclusively so. In this regard the *Thirty-First Yearbook*, page 148, states:

> "Some have contended that no illustrative material should be used except that which is in the natural environment of the school. This seems to be a very narrow interpretation of illustrative material. In this day when the child listens to the events happening in Antarctica, or other far parts of the earth, in which his environment is spreading out so that the whole world comes into his own home in one way or another, to restrict the illustrative material to local, indigenous objects seems, indeed, to be inexcusable."

The subject matter of The How and Why Science Series has been arranged to appeal to as many different groups as possible. Biological units have been chosen in such a way that different sections of the United States are represented. Illustrative material is taken from the East, the West, the Middle States, and the South, thus broadening the scientific concepts acquired by the children using these books.

VOCABULARY TREATMENT

Background of experience and facility in the use of oral expression are prerequisites to the understanding of printed material but are not the sole factors involved in reading that material. Word pronunciation and mastery are factors of equal importance.

To this end, the authors of the primary books of The How and Why Science Series have constantly kept in mind the problems of vocabulary mastery. Each new word has been checked against the Stone and the Gates standardized lists of vocabulary for the primary grades to determine the level at which the word should

be used. Adequate and consistent growth in expansion of the child's vocabulary, level by level, has been carefully and scientifically planned.

Each sentence in the books has been analyzed with readability in mind. Length of sentence, sentence structure, difficult words, as well as the nature of the concepts involved have been used as criteria for checking readability.

Such minor points as the one dealing with variations have been taken into consideration in writing the text. For example, if the words "help," "helping," and "helpful" were to be used, the base form "help" appeared first when possible. The variations "helping" or "helpful" appeared later. The singular form of a word appears before the plural form when possible. No compound words, contractions, or variants, except those made by adding "s" were used at the first reading level. The introduction and use of such words were carefully planned at each level throughout the series.

As a teaching aid, a list of new words for each book is given in the back of that book, with an explanation of the writers' plan in the introduction, repetition, and use of these words.

Using the latest research on the problem as a guide, the mechanical aspects of the reading have been as carefully worked out in this series as in any basic reading program.

THE COMPANION BOOKS

There is a Companion Book designed to accompany each of the texts. The objectives of each of the primary Companion Books are to:

1. Extend and enrich certain concepts
2. Develop a scientific way of thinking
3. Promote language growth

To arrive at these objectives the following activities have been planned: coloring (governed by knowledge of concept), cutting, pasting, and freehand drawing; matching of ideas; selecting and evaluating ideas; placing ideas in proper sequence; reading statements and matching them with pictures; reading simple problems and solving them; doing simple experiments and recording data by

pictures or other means on their level; doing simple tests of concepts learned.

Most of the activities in the primary Companion Books are ones that primary children can do alone. However, there are a few that will require a little thought on the part of the teacher, and at least some discussion. The authors are convinced that as the children acquire more skills, new learning should take place—that the Companion Books should not be just testing programs but an application of principles and concepts to new situations; that the lessons should require the using of skills which are necessary in gathering scientific data and solving problems to attack problems similar to those the children have read about in the text. The authors are determined that these books shall not be the busy-work type—all coloring, cutting, and pasting. All the work in the Companion Books, if used as designed, should serve as an aid in determining the accuracy of the concepts.

AN OUTLINE SHOWING THE DEVELOPMENT OF CONCEPTS

Although each Teacher's Manual contains a detailed outline for a year's work, it may be helpful here to show in chart form the plan and organization of the entire primary group of the How and Why Science Series.

In an effort to accomplish this purpose, the chart on the next two pages is presented. It is a master chart to show the organization of all five books. An examination of this chart will show that the entire field of elementary science is divided into three main content areas—those of Living Things, Physical Environment, and Health. The horizontal divisions show how the concepts grow from book to book and contribute to principles in the upper grades. Vertically, each column represents in brief the science program presented in a single book.

A large, more detailed chart is published separately. In this separate chart the horizontal development shows in more detail the growth of the concepts, and the vertical columns present more elaborate outlines of the material covered in each book. This separate chart may be secured upon request.

ORGANIZATION OF THE ELEMENTARY SCIENCE PROGRAM IN THE HOW

Content Areas	*We See—Pre-primer*	*Sunshine and Rain—Primer*
LIVING THINGS ANIMALS (*See also detailed chart published separately*) In *WE SEE* these concepts are developed by means of pictures.	There are different kinds of animals. Animals are alive. Some animals will need to be fed in winter. Squirrels, ducks, and turtles all have young. Animals eat many kinds of food. Animals go through changes as they grow.	Animals are affected by the seasons. 1. Animal activities in autumn. 2. Animal activities in winter. 3. People get ready for winter. Animals live in different places, differ in structure, and eat different kinds of food. Animals make tracks in snow or mud by which we can follow them.
PLANTS (*See also detailed chart published separately*)	Plants are alive. Seeds grow when planted. Plants have life cycles. Plants are affected by the seasons—autumn, winter, spring, and summer.	There are different kinds of plants. Plants grow in different places. Plants are affected by the seasons. 1. Trees in autumn. 2. Trees in winter. 3. Trees in spring. 4. Trees in summer.
THE BALANCE OF NATURE (*See also detailed chart published separately*)		Children can make simple homes for animals.
PHYSICAL ENVIRONMENT WEATHER AND SEASONS (*See also detailed chart published separately*)	The earth is made up of land, water, and air. We have day and night. There are different kinds of days. We have four seasons. The change of seasons affects animals, plants, weather, and length of day and night. Air is all around us. We see rainbows in the sky. We see rainbow colors in water.	The land, water, and air are farther away than we can see. We travel on land and water and in the air. Rain, fog, and snow are water. Water has different forms. Length of day and night changes.
THE SKY (*See also detailed chart published separately*)	The sun shines on the earth and makes day. We can see the moon and stars in the sky at night. We are in the earth's shadow at night.	Light from the sun makes us warm. Light from the moon and stars helps you see at night. Sunlight helps things grow.
EARTH STUDY (*See also detailed chart published separately*)	The earth is large. The earth is land, water, and air. Seeds are planted in soil. Air is all around us.	The earth is very, very large. People, other animals, and plants live on the earth. We can travel over the earth.
FORMS OF ENERGY (*See also detailed chart published separately*)	We use electricity in our homes. A magnet pulls some things.	The sun gives us heat.
SOUND (*See also detailed chart published separately*)		
BUOYANCY (*See also detailed chart published separately*)	Boats float on water.	Boats float on water. Kites float in the air.
MACHINES (*See also detailed chart published separately*)	We use machines in our home. Machines make work easier.	A windmill is a machine. Windmills do work.
HEALTH GROWTH CLOTHING BODY—PARTS AND FUNCTIONS CLEANLINESS FOOD POSTURE EXERCISE AND PLAY SLEEP AND REST COMMUNICABLE DISEASES SAFETY REPRODUCTION OF LIFE	Plants and animals need food and air to grow. Wear seasonal clothing. Keep your body clean. Eat the right food. Play out of doors. Cross streets carefully. Do not play in the street. Animals and plants make others like themselves.	All living things need food and air to grow. Seasonal clothing. Ready for school. Good foods. Ways of storing food for winter. Seasonal play. Colds are communicable. Children with colds should stay at home. Going to school. Butterflies reproduce. Bulbs make new plants.

AND WHY SCIENCE SERIES, PRE-PRIMER THROUGH THIRD GRADE

Through the Year—Book I	*Winter Comes and Goes—Book II*	*The Seasons Pass—Book III*
Robins, chickens, moths, butterflies, toads, and mammals all have young. Animals grow and develop. Animals eat different kinds of food and live in different kinds of places. Animals are affected by the seasons. 1. Animal activities in the spring.	Animals are able to survive the changing seasons. 1. Insects 2. Spiders 3. Fish 4. Birds 5. Amphibians 6. Reptiles 7. Crayfish 8. Mammals 9. Earthworms Animal tracks may tell a story.	Animals are protected in many ways. 1. Some animals migrate. 2. Some animals hibernate. 3. Birds care for their young. 4. Some animals are protected by their structure. 5. People help protect birds and pets. 6. People are protected by clothing and shelter. 7. Each animal is fitted to the kind of place in which it lives.
Plants are affected by the seasons. 1. Plants in spring. 2. The bean cycle.	Plants are able to survive the changing seasons. 1. Trees are plants. 2. Seeds are scattered in many ways. 3. Bulbs have stored food which helps them to grow. 4. How seeds grow. 5. How wild flowers survive.	Plants are protected in many ways. 1. Some trees lose leaves and have winter buds. 2. Plants produce new plants in different ways. 3. Plants need soil and water. 4. People help protect wild flowers. 5. Plants need a favorable climate.
A home for water animals.	How to make terraria for caterpillars and spiders. How to make an aquarium.	How to make a terrarium for snails. Aquarium vs. terrarium.
Rivers are enlarged in spring. Heat makes water go into the air. Rain comes from clouds. A thermometer shows how hot or cold the weather is. Wind is air that is moving. Weather changes. Rainbows are made when the sun shines on rain. Rainbow colors may be seen in several places. Fire needs air to burn. The wind, sun, and water affect rocks.	Weather changes. Weather in many places. We read a thermometer above or below zero. Water 1. Evaporation and condensation. 2. Different forms. 3. Effect of lack of water. How clouds are made. Animals and fire need air. The weather vane tells what kind of wind is blowing.	Day and night are caused by the rotation of the earth. Thermometers have many uses. Rainbows 1. Sunlight makes rainbows. 2. Sunlight has all colors in it. Air 1. Air takes up space. 2. Air has pressure. 3. Air expands when heated.
The sun gives heat and light. Colors are in the sunlight. The sun and stars are always shining. Stars are far away. Stars make pictures in the sky. We can tell directions by the sun and stars.	The moon seems to change in size and shape. Star pictures—Big and Little Dippers, Orion, Milky Way The North Star is part of the Little Dipper. The North Star helps us tell directions.	The causes of the moon phases. Constellations—Cassiopeia Dippers Orion Relative sizes of sun, earth, and moon. The needle of a compass points north. A compass helps us tell directions.
Rivers and mountains are part of the earth's surface. We put soil into an aquarium. Seeds need good soil to grow. There are different kinds of rocks.	Tree roots are in soil. Some things dissolve. Some do not. Some things form crystals. Soil holds water that plants use. Caves are made in the earth. The earth is round like a ball. The earth has gravity.	How trees use water from the soil. How soil is made. There are different kinds of soil. How soil is carried. Fossils. Different kinds of rocks have different names.
The wind helps things fly. A magnet will pull things made of iron. Electricity makes some things move.	The sun helps living things grow. The wind does work. A magnet has N and S ends. Electricity makes heat and light.	Heat breaks up rocks. The wind does work. Air pressure can be made to work for us. Lightning is electricity.
		Our ears help us hear sound. A thing must vibrate to make sound.
Some things float. Some things do not float.	Boats float.	
An engine is a machine. Engines do work.	Windmills do work for us. A seesaw does work. Engines help move airplanes. Wheels make work easier.	Levers make work easier.
Living things must have proper care to grow. Proper clothing protects our health. We breathe through our noses. Wash hands to get rid of germs. Germs may make one sick. Cleanliness with food at the seashore. Indoor and outdoor play. Rest after play. Early to bed. Robins, chickens, rabbits, toads, butterflies, moths, and mammals all have young that grow up to be like their parents.	Sunshine helps plants and animals to grow. Seasonal clothing. Care of teeth. Soap and water for cleanliness. What to eat. How to eat. How to stand and sit erect. Play out of doors. How to put out a fire. Insects, plants, amphibians, reptiles, crayfish, squirrels, and birds all have young.	Our bodies need good food, fresh air, and sunshine. Wool, cotton, silk. Eyes, ears, nose, mouth, teeth, skin. Care of skin. Milk and vegetables. Value of good posture. Vacation fun. 8 o'clock for eight-year-olds. Quarantine. How to cross a street. Insects and birds lay eggs. Young mammals are born alive.

THROUGH THE YEAR—BOOK I

THE PLAN OF THE BOOK

In THROUGH THE YEAR, the authors have worked toward building up science concepts—ideas that are common to the experiences of all children but which may not be interpreted unless some attention is given to them. These ideas are begun very simply in the Pre-Primer and enlarged upon in the Primer.

The authors believe that the child's first introduction to a concept is very important. They have tried to build these concepts slowly and accurately. If the teacher will follow the units through the first three books, she will see how each one is developed, first with pictures, then text including stories.

The organization and content of THROUGH THE YEAR and the Companion Book which accompanies it, suggest a program much broader than the content of the books themselves. Real situations are developed and standards are set for further reading, observing, questioning, and experimenting.

PROBLEMS PRESENTED IN *THROUGH THE YEAR*

		Pages in *Through the Year*
PROBLEM I	What happens to animals in spring?	
	1. The robin cycle	4–11
	2. The chicken cycle	12–21
	3. The rabbit cycle	22–25
	4. The toad cycle	76–85
	5. Summary of living and non-living things	26–29
II	How does weather change in spring?	30–37
III	How does the sun affect us?	38–44
IV	How do we measure heat?	45–46
V	What makes some toys work?	47–57
VI	What makes the wind?	58–60
VII	Why is air important?	61–65
VIII	How can we tell about the kind of weather?	66–69
IX	What are some of the signs of spring?	70–75, 86–99
X	How is an aquarium made?	77, 78
XI	How do seeds make more seeds?	100–105
XII	How do some mammals care for their young?	106–111
XIII	What can we see in the spring sky?	112–117
XIV	Why are rocks important?	118–121
XV	How can we stay well?	122–126

ACTIVITIES USEFUL IN SOLVING THE PROBLEMS IN *THROUGH THE YEAR*

ROBINS

Pages: 4–11

Concepts:

Robins come back in the spring.
Male robins return first, then the female robins.
Male robins have darker heads and breasts than female robins.
Male robins choose the nesting territories.
Female robins choose the nesting sites.
The female robins make the nests.
The nests are often made in trees.
It takes a robin about a week to make a nest.
She makes it of grass and mud.
The female lays four blue eggs, one each day.
She sits on the eggs for about two weeks before they hatch.
The little robins have no feathers, and are helpless.
Both parents feed the young.
Young robins grow fast and soon have feathers.
Their breasts are spotted and their tails short.
One day they are too large to stay in the nest.
One by one they fly to the ground and follow their parents, begging for food.

Suggested Questions:

What does a robin's song sound like?
What color are robins?
Are they all the same color?
How can you tell the mother and father robins apart?
What is the mother, or female robin, bringing to the tree?
How does she make the nest?
How does mud help in making the nest?

Suggested Activities:

This is the first story illustrating life cycles of animals. These cycles further develop and round out the concepts of animal life begun in WE SEE and SUNSHINE AND RAIN.

Robins are found in almost every yard. Probably most children have seen robins getting worms, singing, and building nests. Yet few adults can tell accurately the life history of the robin.

Because it is so easily observed, the robin is a good bird to use for starting bird study in the lower grades. The story in the book gives some of the things children may see for themselves.

Children should begin learning to observe and record observations accurately. When the male robins first return, the children may notice that the robins sing from certain trees. If the teacher is observing, she will note that these robins are choosing territories and outlining these territories by singing from trees or fences surrounding them. The male birds may have many fights with each other to determine which one has the rights in the territory.

When the females return, the children should notice the difference between them and the males. The children may see males building nests but if they watch closely they will see that the nests made by the females are the only ones that are used. The males' nests are just dummy nests. Their purpose is not definitely known.

The process of bringing mud, grass, a few small twigs, and other nesting material and the method of putting them together may often be watched from a window. Notice how the robin turns her body around and around as she shapes the inside of the nest. Robins are such fearless birds that they often build in places convenient for study.

The children may put out pieces of string or yarn to entice robins. Sometimes an orphan robin is brought to school. It may be fed worms, berries, sugarless custard, bread, and hard-boiled eggs. Young robins are easily raised and become very tame, but there is danger of their being caught by cats when released. However, children learn so much by such an experience that it is well worth while.

Robins belong to the thrush family and the young show the typical spotted breast of that family. Although we do not think

that isolated bits of information are important as teaching ends, we believe that if the teacher knows such details, she can use them. Knowing a few family characteristics is a big help in identification of birds. As a child accumulates a few of these facts, he can use them to help to identify birds he sees. It gives him much more satisfaction to have a tool which he himself can use than to have an adult merely tell him.

CHICKENS

Pages: 12–21

Concepts:

Hens are birds.
They make nests and sit on their eggs in the spring.
A hen can sit on fifteen eggs.
If a hen laid an egg a day in the nest, as a robin does, it would be fifteen days before she could start sitting. So we put eggs into the nest for her.
She sits for three weeks before the eggs hatch.
Eggs that develop dark spots in them have chickens in them.
The hen turns the eggs every day. She can turn them without breaking them.
The eggs hatch in twenty-one days.
When the little chickens hatch, they are covered with down.
Chicks are able to walk as soon as they are dry.
Chicks do not eat at first.
The hen does not feed the chicks but shows them how to find food.
As the chicks grow, their feathers grow.
When the chicks have grown to be as large as their parents, they look like them.

Suggested Questions:

Do any of you have chickens at home?
How are chickens like robins?
How are they not like robins?
What is a female chicken called?
What is a male chicken called?
How does a hen make a nest?

Suggested Activities:

Paralleling the observation of the robin cycle is the cycle of a chicken. Here is a domesticated bird whose young are downy and able to run about when hatched, in contrast to robins, whose young are naked and helpless.

A nest box that has proved very satisfactory was devised by a first-grade teacher. She had a box made that just fitted the outside of the window. It was placed so that the window could be closed. The children could look through the window at the hen, or the window could be raised and the hen cared for.

A nest of straw was placed at one end of the box and the pan of water and food at the other end. By having the box outside the window, no unpleasant odor came into the room. The hen was allowed to exercise in the room every day.

The days that the hen was on the nest were crossed off on a big calendar, and a record kept of each day. About half way through the incubation period the eggs were candled. This was done by rolling a piece of heavy paper to form a cylinder the size of an egg. One end of the egg was inserted in the end of the cylinder and held toward the light while a child looked into the other end of the cylinder. Each child looked first at a fresh egg, noting that it looked pink. An egg with a chick in it looked dark. The dark eggs were marked, and all put back under the hen after the examination. A check was made when the eggs hatched.

One child wanted to break one of the eggs that did not have a chicken in it. He was allowed to do so. This led to a discussion of why some eggs had chicks in them and some did not. Many good reasons were suggested such as that the eggs were chilled, the eggs were too old, the eggs were not fertile.

This is a valuable opportunity for the teacher to very naturally point out the necessity of a male element in the egg. How she does it depends upon her group of children, their backgrounds, and her own ability to translate scientific facts into first-grade concepts. The children who were watching robins know that the male and female mate before nest-building and egg-laying take place. Most first-grade children will not question further. If they do, the teacher should try to answer their questions simply and directly. She should not make the mistake of thinking that she must explain

the whole process of reproduction in answer to a child's simple question. She should go only as far as their curiosity leads, but she should be truthful. If the teacher does not know the answer or is not sure, she should say honestly that she does not know but will try to find out. The bibliography given in this Manual will help her to find out.

HOW RABBITS GROW

Pages: 22–25

Concepts:

Rabbits do not lay eggs. Their young are born alive.
Little rabbits are helpless when born.
The mother rabbit hides the young until they are old enough to walk.
They get milk from the mother's body.
Little rabbits grow teeth soon and can eat carrots and other plants.
Little rabbits look like their parents.
Rabbits are covered with fur.

Suggested Questions:

Do any of you have pet rabbits?
How do they eat?
How do you care for them?
Do they lay eggs as chickens do?
How do the little rabbits look when they are born?
Are they like kittens or puppies?
Can they take care of themselves as little chickens can? What other animals care for their young?
How do they get their food?
What covers their bodies?

Suggested Activities:

This story gives the life cycle of a common mammal. By means of pictures and text it develops the most outstanding characteristics of mammals—that they are covered with fur, nurse their young, and bear them alive.

The teacher should try to borrow some rabbits and keep them in the room for a week or two. The children should discuss how they will care for the rabbits. They may read the story in the book to help them decide on the way to care for the rabbits. They may discuss the care of any pets they may have at home.

When the teacher asks about other animals that care for their young, the children may suggest birds. She may then direct their attention to the characteristics of mammals by asking, "Does the female rabbit feed her young in the same way that the female robin did?" Through comparison she can lead them to give the characteristics of mammals.

The animals that are commonly called rabbits are of two groups that differ in some ways. Jack rabbits and snowshoe rabbits are often called hares in children's stories. Hares have better developed hind legs than the other group to which the cottontail belongs. Also, hares are better developed when born than the other group, since their eyes are open. Young cottontails are naked and blind when born. This explains seeming discrepancies in children's stories about rabbits.

ALIVE AND NOT ALIVE
WHAT ANIMALS EAT
WHERE ANIMALS LIVE

Pages: 26–29

Concepts:

Plants and animals are living things.
Living things must have food, water, and air.
Living things grow.
Stones are not alive.
They do not need food, air, and water.
Stones do not grow.
Some animals eat plants.
Some animals eat animals.
Some animals eat both plants and animals.
Some animals live in cold places.
Some animals live in warm places.

Suggested Questions:

How do you know when something is alive?
What must an animal have in order to live?
What does a plant need to make it live and grow?
What do both plants and animals need?
How can you tell when something is not alive?
Name all of the things you can see that are not alive.
What do the animals in this room eat?

Suggested Activities:

These pages summarize the concepts of living and non-living things started in WE SEE. The children might go for a walk, finding as many of each group of things as possible. Each time a child names something he sees, he should be asked to tell how he knows it is alive or not alive.

It is usually difficult for a child to think of himself as an animal, but if he keeps thinking, "Everything that lives is a plant or animal; if it isn't a plant, it must be an animal," he will soon realize that since he is alive and is not a plant, he must be an animal.

The only purpose for this type of summary is to help orient children in their environment. It can be a game which is fun while they are learning basic science concepts. If their environment is cold, they can name other animals, such as the snowshoe rabbit and ptarmigan that are protected by change of color. If their environment is more tropical, they can likewise name animals that are protected from the heat as the horned toad is.

These pages can also be used to compare types of animals as to their coverings, methods of food-getting, and breathing. As in all of the pages in the first-grade books, an attempt has been made to teach by pictures where text would be too difficult.

JACK AND COWBOY HAL

Pages: 30–37

Concepts:

People live in different kinds of places.
In spring, ice and snow melt except on the tops of high mountains. The melting snow makes rivers.

It often rains a great deal in spring.
Rain clouds are dark.
Water goes into the air and makes clouds.
A cloud is made of tiny drops of water.
Heat makes water go into the air.

Suggested Questions:

How does the weather change in spring?
What happens to the ice and snow?
Where does rain come from?
What makes clouds?
Where does the water go when things dry?
What makes water disappear from a pan on the stove?

Suggested Activities:

This story introduces Cowboy Hal and Jack, who give a natural setting for plants and animals found in the West. The western setting should be emphasized and the fact that people live in different environments. Some of the children may have relatives living in different parts of the world and can tell what they know of the weather and seasons in those places. Discuss the clothing worn by cowboys, and why they wear such things as boots and chaps. Discuss the mountains as being higher, farther up in the air, therefore colder than the plains.

If the story is read at the time when snow is melting and making little rivulets, the children may observe these and see how tiny ones converge to make larger and larger ones. This process may be likened to the way real rivers form.

The children should observe clouds and notice that the dark ones are nearer the earth and usually indicate rain or some other type of precipitation.

The concept of evaporation may be introduced in the first grade by way of familiar experiences. The word isn't used in the text because of reading difficulty, but may be used in discussing the process. Many first-graders already know the word and will use it when asked what happened to the water in the aquarium or water used when the blackboard was washed.

Many simple experiments may be done with evaporating water, which help to demonstrate and give meaning to the word *evapo-*

rate. Set pans or jars of the same size, containing equal amounts of water, in different places such as (*a*) out of doors, one in sunshine and one in shade; (*b*) in the room, one in a cool place, one in a warm place; (*c*) one container covered, one uncovered. Results should be noted at intervals and a record kept of which evaporates first, second, and so on. Discuss the reasons for these results.

Children should be allowed to tell of their own experiences in having water evaporate, such as from raincoats, clothing, paste, sandwiches, and other things. If there are growing plants in the room, cover one with a glass jar and notice the drops of water forming on the inside of the jar. Also, notice the water that forms on the underside of the cover of the aquarium. Though condensation isn't taught in this book, through these experiences children begin to get the idea that when water goes into the air, it comes out of the air again.

Jack's experiment should be repeated by the children. If they do it after looking at the pictures and before reading the story, it will be much more interesting to them. The pan of water may be heated on an electric plate. Before it gets hot enough to boil, children should feel the air above the pan. They can feel moisture condensing on their hands long before they begin to see a cloud. This helps them to get an accurate concept of steam and water vapor. Neither steam nor water vapor is visible, though the common misconception of steam makes this hard to teach. Feeling moisture in the air before they see it helps to fix the correct concept. As the water is heated, from time to time let a child measure the depth in the pan with a stick. The children will see that the amount of water gets less and less.

When a cloud does appear above the pan, let the children point to the space between the water and the cloud. This is where the steam, or "water in the air," is.

SHADOWS

Pages: 38–39

Concepts:

The sun affects us in different ways.

The sun makes the earth light.

When something is between the sun and the earth so that the light can't go through, it makes a shadow.
A shadow is a dark place where light doesn't fall.

Suggested Questions:

Can you see any shadows in this room?
When do you see your shadow?
Does your shadow always look the same?
When is your shadow long? When is it short?
What makes a shadow?

Suggested Activities:

An understanding of shadows helps to clarify many natural phenomena such as night and eclipses. Night is when our side of the earth is in a shadow. Eclipses are caused by the shadow of the earth or moon. Shadows may be used to help children with the concept of the earth's rotation. They will help in telling directions. Even on a cloudy day a shadow is cast by an object.

There is something fascinating to children about shadows. They enjoy shadow plays, making shadows on the wall, and experiments with shadows. In a darkened room a movable light, such as a desk light, may be used to demonstrate the effect of changing positions on the shadow. Using a child as the object, hold the light in one position and let a child walk away from the light. Then with the child standing still, move the light from behind, to above and in front of him. This is similar to what happens at different times of the day.

Though sundials are no longer used for telling time, if the teacher wishes to make one, she can find directions in the reference books listed. It is useful to be able to approximate the time by the sun. A tree or a post may be located on the school grounds, and stones used to mark the shadows at different times during the day. If this is done for several weeks, the children will begin to notice that the shadow is getting shorter at noon as spring advances. This is, of course, due to the changing position of the earth in relation to the sun. This is too difficult for first-graders to understand but even noticing that the sun is higher in the sky is basic to later understanding of the cause of the seasons.

A MORNING RIDE

Pages: 40–44

Concepts:

The sun rises in the east.
The sun is overhead at noon.
The sun sets in the west.
Sunlight makes colors in the sky.

Suggested Questions:

Where do we see the sun early in the morning?
Where is the sun at noon?
Where is the sun in the afternoon?
What colors do you see in the sky in the daytime?
What color is the sky at night?
What makes the colors?

Suggested Activities:

The purposes of this story are to teach directions and some of the effects of the sun upon the earth. Many people never have a good sense of direction because they were not oriented in childhood. The easiest way to gain a sense of direction is by the sun and stars. A knowledge of shadows will help to locate the sun, even on a cloudy day. The moon also helps in the same way.

Children should go out of doors at different times during the day and locate the sun. They may practice finding the other directions by facing east, west, north, and south. Then back in the building they should again locate the sun and practice finding the directions. This is one science concept which is important enough to justify drill. It is a safety measure which may save a person from being lost at some time in his life.

In WE SEE, attention was called to the fact that the sunlight had the colors of the rainbow in it. In this story in THROUGH THE YEAR, the red and blue of the sky are mentioned. These colors are also parts of the sunlight. How they are formed is too difficult a concept for first-graders, but the children can learn that sunlight is the source.

The fact that we get light and heat from the sun is also brought out in this story.

HEAT AND COLD

Pages: 45–46

Concepts:

We use a thermometer to tell how hot or cold the air is.
When it is cold, the red line is short.
When it is warm, the red line is longer.

Suggested Questions:

Have you seen one of these? (holding up a large thermometer)
How does your mother know how warm the room is? baby's bath? her oven?

Suggested Activities:

A good time to introduce the thermometer is when there is a decided change in the weather and some remark is made about it, or if the room is too warm or too cool. The more naturally it can be introduced, the more valuable the learning situation.

If one of the large thermometers such as one sees on store buildings can be obtained, it will be easy for the children to see the red line. First-graders can't read a thermometer but they can see that the liquid goes up and down. They can hang the thermometer in the room for a while and put a thumb tack at the top of the column of liquid, then hang it outside and see what happens. A hook can be fastened just outside the window so that the thermometer can hang in full view through the window and also be unhooked and brought into the room.

A NEW TOY

Pages: 47–50

Concepts:

Magnets make some things move.
A magnet pulls things made of iron and steel.
A magnet does not attract things made of wood, glass, or rock.

Suggested Questions:

What can pick up nails, yet has no hands?
What things will a magnet pull? How can you find out?

Suggested Activities:

Most children who have played with magnets are fascinated by them. Toys like magnetic fishponds, magnetic jackstraws, and slates make use of this interest.

The children should be allowed to play with horseshoe magnets, trying them out on various things. Each child should have an opportunity to handle a magnet and find out for himself the things that it will pull. Let the children make two piles, one of the things the magnet *will* pull, another of the things the magnet *will not* pull. They will discover that all of the things in the first pile are made of iron or steel. Of course steel is made from iron. If by chance they put a lid made of so-called tin in their pile, the teacher should scrape some of the coating off and let them see that the lid is really made of iron.

The only concept we attempt to teach about magnets, in the first grade, is that they attract things made of iron and steel and do not attract things not made of iron and steel.

JIMMY'S TOY

Pages: 51–53

Concepts:

Some things are moved by electricity.
We can turn electricity on and off with a switch.
Electricity has to go around a track to make a train go.

Suggested Questions:

What makes a vacuum cleaner (or any electrical appliance) go?
How can you make it go on? Go off?
How does the electricity get into the cleaner?

Suggested Activities:

Nearly all children today are familiar with electrical appliances and use them every day. The ideal time to use the story is when some question arises concerning electricity, such as, "Why are there two prongs on a plug?" or "Why doesn't an electric train go if there is a gap in the track?"

If possible, let a child bring a toy train to school and experiment

with it. Try connecting two pieces of track with strips of wood and see what happens. Look at plugs and sockets to see that the two connect so that electricity can make its circuit.

Discuss safe practices in turning electricity on and off. Caution the children not to touch switches or wires with wet hands. Also, discuss all the things the children can think of that run by electricity.

WHAT FLOATS?

Pages: 54–57

Concepts:

Some toys float. Wood floats. Iron does not float.
The wind can move a toy boat on the water.

Suggested Questions:

What happens to things that fall into the water?
Do they all sink?
What kinds of things float? Have you any ideas as to why?
How can we find out what makes them float?

Suggested Activities:

Try dropping all kinds of things into a large pan of water or an aquarium. Try such things as stones, nails, marbles, corks, pieces of wood, and paper. Then try a dry sponge. After seeing it float, let a child squeeze it under water. As air bubbles come out, the sponge will sink. Float a small-necked bottle, then watch it sink as air comes out and the bottle fills with water. Likewise, a balloon floats until filled with water. The children should begin to see that anything lighter than water, floats; anything heavier, sinks. When something like a steel ship, heavier than water, floats, it is because of the air in it. It is something like the bottleful of air.

On page 56, the cork, tire, boat, wood, fishing cork, and ball should float.

On page 57, the magnet is pulling the nails. Let the children make boats of corks with paper sails, and masts made of darning needles. They can pull them with a magnet and discover why the boat moves on page 57.

WIND

Pages: 58–60

Concepts:

Wind makes kites move in the air.
Wind is moving air.
The wind blows a great deal in spring.
We cannot see air.
We feel air when it moves.

Suggested Questions:

Have you ever flown kites?
Can you feel the wind pulling the kite?
Where else have you felt the wind?
Can you see things the wind does?
Can you see the wind?

Suggested Activities:

The purpose of this story is to introduce the concept of air by way of a common experience. The children should go for a walk and look for things that the wind is doing. Notice tree branches, clothes flapping in the wind, and other manifestations of something they cannot see.

They may make kites and paper windmills to see how we make use of the wind. They may run with strips of paper to see how the air will make them fly. They can feel the air by whirling with their arms outstretched or by waving their hands in the air. With an old-fashioned bellows, enough breeze can be made to blow bits of paper. Letting the air out of a balloon or blown-up bag will start quite a breeze. Children of this age do not usually ask the cause of wind so no attempt is made to explain it.

AIR

Pages: 61–65

Concepts:

Air is all around us.
Air is real.
We must have air to live.

All animals must have air to live.
Fire must have air to burn.
Air helps birds to fly.
Air helps airplanes to fly.
Air holds gliders up.

Suggested Questions:

What is all around you, yet you can't see it?
How do you know that air is there?
What has to have air?
What is the best shape for a glider?

Suggested Activities:

After children have felt wind and discussed it, it is much easier for them to get the idea of air as a real substance. Many common experiences such as those suggested in the story, will help to clarify the concept. Tossing dandelion and milkweed seeds into the air and watching them float on air currents; blowing soap bubbles and watching them float; dropping such things as snow, ice cubes, and dirt into a glass of water and watching air bubbles come out; moving a door back and forth rapidly to feel the pressure of the air; every simple activity the teacher can think of should be used to help fix the idea that air is everywhere on the earth.

Watch birds soaring. They are floating on the air currents much as a boat floats on water. The upward pressure of the air is greater on their outspread wings and bodies than the pressure from above. When that ceases to be true, they must move their wings to make that pressure greater. Children can move their arms as a bird does its wings, cupping their hands to "catch" as much air as possible. They can feel the pressure of air on the palms of their hands, as they come down. If they had as much surface on their arms as a bird does on its wings, they might climb into the air also, provided, of course, that their bodies were light like a bird's, and shaped the same.

Let the children try making gliders of paper. They can make different shapes and discover the best shape to use.

We don't expect first-graders to understand much about what makes things fly. The ideas that air helps things fly; that birds, planes, kites, and gliders have to have some "push" to get them started; and that the pressure of air under them has to be greater than that above for them to stay in the air, are understandable at this level and will contribute to a fuller understanding later on.

WEATHER

Pages: 66–67

Concepts:

The thermometer helps us to know the kind of weather.
The sky helps us to know the kind of weather.
The clouds, rain, or snow help us to know the kind of weather.
The way the wind blows helps us to know the kind of weather.

Suggested Questions:

Can you tell what kind of weather we are having?
What helps you tell the kind of weather?

Suggested Activities:

This is really a review of some of the things the children have been learning. They use the thermometer to tell about the weather. Whether it is hot or cold can be told by the length of the line (not by degrees). The children also make a record of the weather. Recording data is one of the skills used in problem solving.

To gain this skill, children should observe the weather for a few weeks and the teacher should record their observations on a chart. If they are using the Companion Book, page 21 gives the children a place to make individual records.

These things should be observed and recorded:

Sky—clear, cloudy, overcast
Clouds—white, feathery—white rolls like cotton—dark rain clouds
Wind—strong, light, none
Temperature—hot, warm, cold, cool

Pages: 68–69

Concepts:

The sun shining on rain makes rainbows.
Rainbow colors are in the sunlight.
When sunlight shines through an edge of glass, it makes the colors.

Suggested Questions:

When do you see rainbows?
Where are you when you see them?
Is the sun behind you or between you and the rainbow?
In what other places do you sometimes see rainbow colors?

Suggested Activities:

A rainbow is one of the most difficult of all natural phenomena to explain technically. WE SEE shows two common experiences that children have with lights being broken up into colors. In a true rainbow, each drop of water breaks up the light in a complicated way and the colors from all the drops are assembled because of their common wave lengths. From every angle we see a different rainbow. Two people do not see the same one. To try to explain this to little children scientifically would be foolish. If they get the concept that sunlight makes colors when it shines through raindrops, drops of spray, soap bubbles, cut glass, diamonds, and so on, they will be ready later to learn more. If they ask why, the teacher will have to explain as best she can that all the colors are in the light and that the raindrops separate the colors so they may be seen. She can make a color wheel of cardboard and spin it on the end of a spool to show how all the colors combine to make white. If a prism is available, let the children experiment to make the spectrum. The prism has to be held in such a way that the sunlight passes through one face and comes out another face. By turning the prism in a beam of light, the children will discover this.

Pages: 70–75

Concepts:

Buds on trees swell and get green.
Some buds open and make leaves, some make flowers.
We find toad eggs in the spring.
Birds that have been away all winter are returning.
Dandelions and other wild flowers bloom in spring.
Tulips and other bulbs planted outdoors are coming up.
The grass is getting green.
The ground freezes at night and thaws during the day.

Suggested Questions:

How do we know when spring is here?
What is happening to the trees and bushes?
What are birds doing?
What is happening to the grass and wild plants?
How is the weather changing?

Suggested Activities:

The purpose of this story is to carry through the observations of seasonal changes started in autumn. The children may go to the same places they went in autumn and notice the difference in plant and animal life. The teacher should go for the walk first and notice certain "signs of spring" in the environment. The ones given in the story are common in many parts of the United States, but not all. Neither are the plants and animals mentioned the same everywhere. The teacher, knowing her own locality, can adapt the story to local conditions.

The woodpecker mentioned is the red-headed one, a migrant, as differing from the downy woodpecker in SUNSHINE AND RAIN. It is found in most sections of the United States at some season of the year. The males and females are colored alike, while the immature birds have dark-gray heads.

Pussy willows, aspens, and poplars have attractive buds in spring. They are the buds of pistillate and staminate flowers. If put into water they bloom and are no longer so pretty.

Children should observe where melting snow or rains have

washed the topsoil into ponds, lakes, or streams. They may notice how gullies are forming where grass has been worn off along terraces or where paths and roads have been made across fields. The teacher may discuss with them the importance of plants in preventing the washing away of the soil. This situation also may offer an opportunity to point out why they should walk on sidewalks and not cut across lawns. Often these paths become gullies.

The picture of toad eggs at the bottom of page 75 is a little misleading because the artist tried to show individual strings of eggs as they appear when straightened out. Actually, when you find them, they are coiled in such a way as to appear in bunches. One toad would not lay a string around the rocks but would lay them in one place. They look a little like a mass of earthworms when you see them in the shallow water of ponds, pools, or ditches. Each egg is surrounded by its own layers of jelly, then all encased in the string of jelly which is secreted around them as they are being laid.

HOW TOADS GROW

Pages: 76–85

Concepts:

Toads lay eggs in still, shallow water.
They lay the eggs in late spring.
The eggs are in strings of jelly-like material and float on the water.
Toad eggs hatch by the heat of the sun. The female does not sit on them.
Toad eggs will hatch in an aquarium.
Young toads look more like fish than like their parents. They are called tadpoles.
Tadpoles are small and black animals at first. They do not have mouths but cling to the jelly with suckers.
Tadpoles eat water plants (algae).
The hind legs develop first.
When the hind legs develop, tadpoles can no longer breathe under water.

The little toads come out on land, breathe air, and eat insects. They look like their parents.

Suggested Questions:

Where do you usually find toads?
Have you ever found toad or frog eggs?
Where were they? How did you know them?
How would you gather toad eggs if you wanted to watch some hatch?
Where would you put them?
How would you take care of them until they hatch?
How are young toads different from their parents?

Suggested Activities:

We have chosen the story of a toad instead of a frog because toads are found in more places than frogs, but the life histories of toads and frogs are so similar that the teacher may use either. They represent the class of animals called amphibians, that spend the first part of their lives in water and the last on land.

Toad eggs are found in March or April in ditches, ponds, pools, or even puddles. They are in strings of clear jelly, although in the dirty water in which the eggs are usually found, the jelly looks dirty, too. When the children gather the eggs they should also get some of the pond water, as this is the best water in which to raise the tadpoles. They should also gather some of the green scum (algae) that grows in the pond and put it into the dish with the eggs. The mass of algae supplies oxygen for the developing eggs and later is used for food by the tadpoles.

A flat, shallow glass dish is best for raising tadpoles but they may be raised in any dish. The water should be rather shallow so that there can be plenty of air surface. The eggs should be placed where they will get sunshine once a day, but not be too warm. An aquarium is used in the story to teach the children how to make one.

When the eggs hatch, the tadpoles should be put into an aquarium where they will have more water. If there are too many tadpoles, some should be returned to the pond. This helps teach the children conservation and protection.

At first the tadpoles have no mouths—just suckers by which they cling to the sides of the dish and to the jelly. In about a week toad tadpoles develop mouths and begin to eat the algae hungrily. As they grow older the external gills, which at first look like little branches on the sides of their heads, are covered by skin and become internal gills. The children should compare them with fish and notice the absence of fins and gill covers. They should notice also that tadpoles are smooth.

In about six weeks the hind legs appear as little buds near the tail. When they break through, they do look like tails, as the child in the story observes. The tail does not drop off but is absorbed as the tadpole changes to an adult. By the time the front legs have developed, the tail is quite short, the lungs have developed, and the gills cease to function. At this time the tadpoles come to the surface for air, and unless they can crawl out of the water, they will drown. When they have their legs, it is best to take them outside and release them.

Toads complete their transformation in from sixty to ninety days. They come out of the water as tiny toads that will find their way to someone's garden if given a chance. They will live on land the rest of their lives. They become sexually mature in four years and from that time on go to water each spring to mate and lay eggs.

The review in floating bodies suggests a natural way in which the concept may be taught. The children may experiment with various objects to see which float and which do not. Provide pans of water and pieces of wood, metal, paper, cork, stones, and other common materials. The children may find that a brass bowl or a tin cover will float unless tipped, thus reviewing the idea that there is air in the container, and air is lighter than water.

THE FUZZY CATERPILLAR

Pages: 86–87

Concepts:

Woolly Bear caterpillars eat when they first appear in the spring.
They eat, then spin their cocoons.
They use their own hair in their cocoons.

Suggested Questions:

Are all fuzzy caterpillars alike?
What colors are the ones that spin in the spring?
Does a Woolly Bear make the same kind of cocoon as the green caterpillar?

Suggested Activities:

There are several kinds of so-called Woolly Bear caterpillars. Some of them spin in autumn, emerging in the spring. These are yellow, tan, or black in color. The one in this story is the black and brown Woolly Bear, commonly seen hurrying across sidewalks and roads in autumn. Perhaps the line, "Caterpillar, in a hurry, take a walk," was stimulated by one of these. It is the larva of the Isabella Tiger moth. Usually it hibernates in the larva stage under dead leaves or bark, emerging in April or May to eat again, then spin it's cocoon. The cocoon is a thin structure with the larva's hairs woven in with the silk.

Ten days to two weeks after spinning, the adult moths emerge, mate, lay their eggs, and die. They are a dull yellow with orange bodies marked with black. The food of the larva is a large variety of weeds.

Children should have experiences with as many moths and butterflies as they find, learning the satisfaction of raising them. They will enjoy watching and releasing moths, and have no desire to catch and kill the harmless ones.

Refer to Sunshine and Rain, pages 50–54, for the first part of the story about the fuzzy caterpillar.

A MOTH

Pages: 88–91

Concepts:

Polyphemus moths emerge from their cocoons in spring.
The cocoons were made by big green caterpillars.
A moth comes out of a cocoon. A moth has a big body. It flies at night.
A butterfly comes out of a chrysalis. A butterfly has a slender body. It flies in the daytime.

Suggested Questions:

What makes a cocoon?
How does it make the cocoon?
Where has the caterpillar been all winter?
What happened to it inside the cocoon?
How can you tell a moth from a butterfly?

Suggested Activities:

Part of the fun of collecting caterpillars is in waiting to see what they become when transformed. The green caterpillar which the children watched spinning a cocoon in the autumn emerges as a beautiful moth in the spring. If the cocoon has been kept in a cool place, like a cellar or a box outside the window, the moth will not emerge until time to mate. Those kept in a warmer place may develop more rapidly.

If one could have looked into a cocoon and observed the changes taking place there, he would have seen that the moth was slowly developing all winter. When the caterpillar disappears beneath its silk cocoon, it continues spinning for about three days. As it spins, it shrinks in size. Then it stops spinning and molts for the last time. The discarded skin and mouth parts may be found inside the cocoon. The caterpillar has formed a pupa that lies quietly in the cocoon unless disturbed. If one picks up a cocoon, the pupa may move. During the pupal stage the outlines of the moth begin to show through the pupa skin. The head, antennae, proboscis, legs, and wings are all distinctly outlined long before the moth emerges. At last the pupal skin splits, much as the butterfly pupal case did, and the moth pushes out. But unlike the butterfly, the moth has to get out of the cocoon. So it excretes a fluid that softens the silk at the end of the cocoon, and pushes its way out.

When the moth first emerges, its body is very large and its wings are folded and crumpled. It will cling to a twig with its wings hanging down as it pumps fluid and air into the wings. If the moth can't crawl to a place where it can cling, the wings will harden out of shape. For this reason, a wire cage is a good place in which it may emerge. A large twig in a jar will also serve the purpose. This experience of being able to watch a moth emerge is rare enough to warrant taking time from other lessons.

Since Polyphemus moths are common in many parts of the United States, this moth has been used in the story. It is so named because of the big single spot in each wing that reminded someone of the one-eyed giant, Polyphemus. As all primary teachers know, the word will be easy for children to learn to read because it is unusual.

Refer to SUNSHINE AND RAIN, pages 50–51, for the pictures and story given there.

EARTHWORMS

Pages: 92–95

Concepts:

Earthworms come to the top of the ground in spring and leave little piles of dirt.

They come out of their holes on rainy days.

Earthworms are animals. They eat, breathe, grow, and move.

Suggested Questions:

Where do earthworms live?

What do you suppose makes them come out on rainy days?

Suggested Activities:

This story was written to answer the question asked by Jimmy. It is a question many children ask and one often answered by adults with the misconception, "It rained worms last night."

The ideal time to use the story is when some child in the group is curious enough to ask about earthworms. The next best approach is for the teacher to notice dead earthworms on the walk and say, "As I came to school I saw a strange sight. Earthworms were all over the walk. Why do you suppose they were there?" Let the children give their ideas. Then she can say, "How do you think we can find out?" Again, let the children suggest ways to find out. They will probably suggest bringing some of the worms into the room. She may let them dig some worms and then say, "I know a story about some children who wanted to find out this same thing. We might read to see what they did." Or, if the group is alert and has enough ingenuity, they may solve the prob-

lem first, and then read to see if they have the same results as the children in the story.

Much has been written about the lowly earthworm and its value to the farmer. The earthworm is an animal having no skeleton, no distinct body parts, no complicated respiratory system. It is lower than insects but higher than starfish, jellyfish, and sponges. Still it must keep its skin moist to allow air to diffuse through its skin into its simple blood system. It has no definite head, but a head end with a mouth. It responds to stimuli, such as light, which repels it; moist earth, into which it will burrow; water, which sends it crawling out of a jar in the story.

Earthworms have no legs, but move by their muscles and tiny bristles on the undersides of their bodies. They pull their food—decaying leaves—into their mouths by a muscular movement of their lower lips.

Since the purpose of the story is to answer a common question asked by first-graders, and not to teach more than they want to know about structure, this information may not be needed.

SPRING IN THE GARDEN

Pages: 96–99

Concepts:

Tulips come up in the spring and bloom.
Tulips grow from bulbs.
There is something in black soil which helps plants to grow.
Some buds on cherry trees open and flowers come out.
Some buds open and leaves come out.
The flowers grow into cherries.

Suggested Questions:

Are tulip bulbs like narcissus bulbs?
Do we plant them in water?
Can we plant narcissus bulbs outdoors?
When do we plant bulbs outdoors?
When do they come up and bloom?
What kind of soil is best for gardens?
How are apple trees and cherry trees different?

Suggested Activities:

The purpose of this story is to stimulate interest in and observation of seasonal changes in the child's own yard and to make him want to help in its care. It also presents some new concepts. As the days grow warmer, plants which have been dormant through the winter start to grow.

The children may bring branches of such shrubs as forsythia, spice bush, redbud, and flowering crab and put them into water. If carefully cut with a sharp knife or pruning shears, many branches of woody plants will bloom in the house. Trees like horse chestnut, hickory, and flowering plum will do likewise. Twigs should be cut close to the main branch, leaving no pieces sticking out to become diseased. They should be cut where they will not spoil the appearance of the tree or shrub. As the buds open the children should notice the scales which drop off as leaves and flowers appear.

If there is a school garden, the teacher may anticipate these spring activities and have the children plant some bulbs out of doors. If they haven't a garden, a few bulbs may be planted in pots and left out of doors until spring. Or a visit may be made to someone's tulip bed, garden, park, or a florist shop to see how the plants grow in soil. Compare with the narcissus which they planted in water.

Though six-year-olds are too young to learn flower parts, or how they function, they can begin to observe that fruits come from flowers. If any kind of fruit trees are near enough for a trip, let the children observe them from time to time to see how the fruit develops.

They may notice the difference between the different kinds of soil. At this age it is merely noticing that good soil is darker than sand and that it contains some food for plants.

PLANTING SEEDS

Pages: 100–105

Concepts:

Beans are seeds.

Seeds have little plants in them.

Plants will grow from the seeds.
Seeds need good soil to make them grow into healthy plants.
Seeds must have water and heat to make them grow.
Roots, stem, and leaves come out of each seed.
They grow into big plants.
Flowers grow on the plants.
The flowers grow into fruits with seeds in them.
We call bean fruits, pods.
The seeds in the pods are like the seeds that were planted. They are beans.

Suggested Questions:

You know that you can grow some plants from bulbs. Do you know what your father plants in his garden?
What happens to the seeds he plants?
What must be inside a seed if it makes a plant?
What are the parts that you see coming above the ground?
What does the plant have under the ground?
You have found out that apple blossoms grow into apples and cherry blossoms grow into cherries. What do you think will grow from the bean blossoms?

Suggested Activities:

This story extends further the cycle of a common garden plant, which is typical of many flowering plants. It should develop the ideas that flowers make seeds and that seeds make plants which in turn make flowers like the original flowers. It contributes basic concepts necessary for a later understanding of the biological principle that all life comes from life and produces its own kind.

Little children enjoy planting seeds and watching them grow, but their interest span is too short for them to carry through much of a garden. The window box or individual small garden plots will be more satisfactory. If each child can plant a few seeds in an individual box or pot so that he can watch it every day, he is happy.

Seeds that grow quickly should be used; also, large seeds. Lima beans, squash, and corn are interesting to watch. Lima beans

planted in a window box early in spring will bloom and make seed before school closes in June.

If it is possible, the planting should be done correctly. Use garden soil. Have a layer of gravel in the bottom of the box and some charcoal to sweeten it. Then sift the soil into the box, filling the box and leveling it off with a stick. Seeds should be planted at a depth of four times their diameter, and the soil pressed firmly above them. Then they should be sprinkled with water.

It is much more natural to perform the experiments showing seed germination after actually planting some seeds. Seeds should be soaked overnight if quick germination is desired. Then they may be put between layers of damp blotting paper, sawdust, or in tumblers full of wet sand. The seeds should be put close to the glass so that the children can see them as they sprout. If children are curious about the inside of the seed, they can open some soaked lima beans and find the little plants inside. Actually everything inside the seed coat is embryo, the large white halves being the cotyledons in which food has been stored. This food is used by the sprouting embryo before it is able to make its own food. That is why it can grow quite a while in sand, sawdust, or between blotting paper. As the plant grows, the cotyledons shrivel. When grown in soil these cotyledons push above the ground, shrivel, and drop off.

Watching beans grow, blossom, and form seeds familiarizes children with the life cycle of a seed plant without any attempt at formal teaching. They have seen roots, stems, leaves, and flowers grow from bulbs. Now they see them come from seeds. They see that the flowers again produce seeds. Of course the teacher does not try to teach them about pollination at this age. But seeing what happens gives them concepts upon which to build when they are old enough to understand more.

Reference can be made to pages 46–48 of WE SEE.

ANIMALS ON THE RANCH

Pages: 106–111

Concepts:

Wild rabbits make nests in holes in the ground or under bushes. The female rabbit lines the nest with fur from her body.

She feeds her helpless, blind young with milk from her body.

Prairie dogs have their young in their burrows. They also feed them milk.

Cows have calves that are able to walk soon after birth.

Calves get milk from their mothers.

Human babies are helpless when born and get milk from their mothers.

Sheep have lambs. Lambs are able to walk soon after birth and get milk from their mothers.

Rattlesnakes are poisonous.

Suggested Questions:

When do most animals have their young?

Have you ever seen little rabbits? lambs? calves? other little animals?

Mother robins feed their young on worms and insects. What do the mothers of animals like cats, rabbits, and cows feed their young?

Suggested Activities:

The children have learned something about the life histories of insects, toads, and birds. They know that toads lay their eggs in the water and go off and leave them; that the young take care of themselves and eat what they find in the water. They know that birds come from eggs and that young robins are fed insects and berries. They know that the parent birds care for the fledglings for a time until they can fly away. They know that tame rabbits care for their young and feed them milk. Now the children learn that animals with fur or hair have their young in a different way from other animals. They learn that they are born alive, and that not only does the mother care for them but she feeds them milk from her own body.

Young rabbits, squirrels, kittens, or puppies all make excellent pets for children to watch and care for. They will learn more about a little mammal by raising one than by anything they can read or be told. Little children are so natural in their reactions to animal behavior and life processes that sex education is no prob-

lem for the wise primary teacher. Spring is the time when most animals are mating and having young. If a litter of guinea pigs, rabbits, white rats, or kittens is born at school, the teacher should answer the questions children ask in as straight-forward, simple a way as she would answer any other question. If no undue emphasis is placed on these questions, they will not seem to be any more important than the ones about feeding or locomotion. Six-year-olds may ask, "How did the little rats get born?" or "Yesterday they weren't here, today they are. Where did they come from?" The teacher may ask, "I wonder if anyone knows." Often another child will volunteer the information that the little ones grew in their mother's body. In answer to the question, "How did they get out?" the teacher may say, "Out of a special opening in the mother's body like the opening in a hen's body where the eggs come out." If a female mammal, like a rat, guinea pig, or small dog is available, the children may be shown the opening. Often they aren't even interested and the next question may be, "How does the rat wash its face?"

Needless to say, a teacher should know her community and how far she is permitted to go in answering children's questions. Since some questions in this field always pop up in primary rooms, it is a wise precaution to meet with the mothers early in the year and ask them what they want the teacher to say in case questions regarding reproduction arise. If the teacher has a wholesome attitude and knows how to handle the subject simply and wisely, she is likely to have the wholehearted cooperation of the mothers. Inexperienced teachers should read one of the good books on sex education listed in the references. Remember that because a child asks one question like, "Where do babies come from?" doesn't mean that he should be given a full account of human reproduction. A simple answer to his question will suffice.

The rattlesnake is brought into this story to teach that some snakes are poisonous. The children have learned that garter snakes are harmless. They may have kept a small garter or grass snake in a terrarium for a while. We want them to know that most snakes are helpful and should be protected. But we don't want them to be struck by a poisonous snake. So we teach them a wholesome respect, even for garter snakes. The rattlesnake is

the most common of the poisonous snakes. Different varieties of rattlesnakes are found in most parts of the United States. In many states it is the *only* poisonous snake. The other three poisonous snakes are the coral snake, the water moccasin, and the copperhead. The teacher should find out which of these, if any, is found in her community.

The children may compare the picture of the rattlesnake with pictures of the garter snake. Notice the broad, triangular-shaped head which flattens when the snake is aroused. Notice also the modified scales—rattles—on the end of the tail. By rapidly vibrating the tail, a noise similar to a buzz saw is made.

All snakes have teeth with which they pull food into their mouths, but poisonous snakes have fangs in addition to their teeth. When they kill their prey, they strike with a forward, downward movement, which drives the needle-like fangs into the animal's flesh quickly. The fangs are hollow, with poison glands at the base of each. They act like hypodermic needles and inject the poison. First-graders do not need to know all of this but if they ask, the teacher should be able to answer truthfully. The reference list has several good sources of information about snakes.

It is a common fallacy that the word *animal* means *mammal.* We should try to give children the correct concept from the beginning, that insects, fish, amphibians, birds, and mammals are animals. All living things except plants belong in the group called animals.

In this story about young animals, children learn two characteristics of mammals—that they are born alive and that they drink milk.

Refer to pages 22–25 for the rabbit cycle.

A NIGHT RIDE IN SPRING

Pages: 112–117

Concepts:

Stars shine at night.
Stars are suns that are so far away they look small.
Stars make patterns in the sky.
At night we can tell which way is north by the Big Dipper.

People should be sure to put out campfires.

Water, dirt, or anything that will keep out air will put out a fire.

Suggested Questions:

What can you see in the sky on a clear night?
Why can you see the stars?
What star can you see in the daytime?
What makes the sun shine?
What makes the stars shine at night?
Can you find the Big Dipper in the sky?
In which direction do you look?

Suggested Activities:

Children are surprisingly interested in the sky. A four-year-old who was allowed to go to sleep out of doors on hot summer nights called one bright planet, her star. She asked her mother how God could have enough hooks in the sky to hang up so many stars. Many children wonder about natural phenomena, among which the heavenly bodies are the most mysterious.

Sky study was begun in WE SEE and if the children are encouraged through the winter to watch the moon and stars before they go to bed, they will develop an interest in them. They should be allowed to tell what they notice and draw pictures on the board of any patterns they see. If they have located the Big Dipper in winter, they will notice that in spring it is in a different position, but still in the north.

They may also tell of a difference in the brightness of stars. This difference, called magnitude, is due to several factors—distance from the earth, size of the star, its age and temperature. All of this is, of course, beyond the comprehension of a primary child. However, the so-called morning and evening "stars," may be explained simply. They are planets, usually Venus. Planets are much closer to the earth than the stars. They do not shine by their own light as stars do, therefore are not hot. They shine as the moon does, by reflected sunlight. If a child asks about them, the teacher may help him to understand why they look so much larger than the stars.

Distance is one of the most difficult concepts to teach, so all that we can hope to give a first-grade child is a beginning of the idea that space is vast. Even an adult has little conception of the size and distance of heavenly bodies.

The fire is brought into this story to teach safety. First-grade children are not supposed to build fires, nor do we intend to have them put out fires. However, fire fascinates children, and they often play with fire when adults are not around. We feel that it is better to teach them how to handle fire and to use matches under supervision than to let that natural curiosity go unsatisfied. Though we hope that they won't have to put out a fire, it might be necessary sometime.

Therefore, in schools where it is not forbidden, the teacher can make a small fire on a metal tray. She should use every precaution as she makes it, asking the children why she uses each safety measure. As a reward for knowing these precautions, different children may be allowed to help. The fire may be extinguished by putting dirt on it. Another one may be put out with water.

Some of the precautions a teacher should use and teach the children are:

1. A demonstration or experiment using fire should always be done on a piece of metal or glass large enough to prevent any possible spreading of the fire. A metal tray or piece of plate glass or table with a metal or glass top will do.
2. All inflammable material should be removed from the table.
3. Children should sit at a safe distance, not crowd around.
4. Persons helping should tie or pin back their hair, ribbons, ties, or other inflammable wearing apparel where they won't fall into the fire.
5. Use safety matches. Strike them away from you, not toward you. Hold the match in a horizontal position, not up or down.
6. After lighting a fire, blow the match out and lay it on the metal tray. Never shake it out. It might hit clothing or hair.

7. Always have a container with water in it near enough to use in case of accident.
8. Do one thing at a time, discussing it with the children. *Drill* on these precautions before *any* experiments involving fire are done.
9. Be sure that the fire is out before leaving the table.
10. If a child is helping, never take your eyes off him for an instant. Explain why to the children. They will co-operate.

Children are eager to learn how to experiment in the right way—the safe way. In twenty years' experience with teaching science to children, the author has never had one child injured. Several times there were near-accidents but there was no panic and the children knew exactly what to do. Children are far more calm than adults in similar situations, if they have learned what to do and how to do it.

AT THE SEASHORE

Pages: 118–126

Concepts:

Sand comes from rocks.
Soil is broken-up rock.
Rocks are broken by water, wind, and sun.
Some rocks are smooth, some are rough.
Some rocks are hard, some are soft.
Rocks are many colors.
Rocks are the hard part of the earth.
We should play out of doors.
We need sunshine and fresh air.
We should wash before eating and after going to the toilet.
We should eat clean, wholesome food.
We should go to bed early and get plenty of rest.

Suggested Questions:

Are all rocks alike?
How can you tell hard rocks from soft ones?
When you pound up a rock what does it make?

When you rub a hard rock and soft rock together, what happens?

Why is it important to wash your hands before eating? after going to the toilet?

Suggested Activities:

Most children like rocks. If they go to a lake, seashore, or any place where there are pebbles they fill their pockets full of them. The shapes and colors attract a child. Teachers can utilize this natural interest to teach concepts about the earth. Since rocks are found everywhere, the material is always at hand. They don't have to be large rocks. Gravel has many pieces large enough for study.

The children should go for a walk and find stones that interest them. Each child may tell the others about the one which interests him most. Ask him to tell why he likes it. He may say that it has a funny shape, or is smooth, or a pretty color, or is white and soft like chalk so that he can make a mark with it.

Ask, "Who thinks he has the softest rock?" or, "Who has a rock he can write with?" Let the child with a soft rock put it on one end of the table. The one with the hardest rock may put his at the other end. Between may go the others in order of their hardness. No equipment is needed for this. If a child thinks his rock is harder than another one, he can find out by rubbing the two together. The harder one will scratch the softer one, the softer mark the harder.

Having arranged their rocks, the children will have gained the concept that some rocks are hard, some are soft. He will also have gained the concept that there is a wide variety in hardness. This idea is basic to an understanding of soil formation.

Some rocks, such as sandstone and weathered granite, may be rubbed together to produce soil. Let the children do this over a piece of paper and discover that they are getting a little pile of sand. They may also find a more powdery soil—clay—which can be tested by mixing with a few drops of water. If it is clay, it will be sticky.

It isn't important that the children know the names of rocks and soils, but that they realize that rocks are the hard part of the earth and that they make soil when broken up. The teacher may go

as far as their interest leads in discussing how this takes place. If a stream is near enough to visit, it will be easy for children to see one way in which rocks are disintegrated, but don't try to force more information than is needed in response to their interest.

The most important of the health concepts presented in this story are that we should wash our hands *before* eating and *after* going to the toilet. Health rules, merely memorized, are usually of little value. At six, if these aren't already habits, they have to be made impressive.

The word *germ* is not an accurate, scientific term, but since it is in the oral vocabulary of most children, it is used here. Popularly it means any disease organism and serves the purpose of teaching when hands *must* be washed.

If the teacher has access to a binocular microscope, one which has two eyepieces, she can use it to advantage in teaching this lesson. Children will say, "We can't see germs on our hands. They don't look dirty." But if they can see the dirt on their hands enlarged, it impresses them. Even a hand lens will help, for looking at a small boy's hands through the lens will show him dirt he didn't see.

An interesting and valuable lesson can be taught here if microscopes are available. Put some common things like a butterfly wing, a feather, and a hair, under a hand lens. Beside it, have the same things under a binocular microscope. Let the children look at the materials through each after looking at them with their naked eyes. A compound microscope is so complicated that most first-graders cannot see much, but if there is one available, they like to try to see through it. The same objects should be mounted for them to see.

Then a few particles of soil should be used. The children will be astounded at the size as they see them through the microscope. Explain that germs are so small that they can't be seen except through a microscope. To prove that things so small do exist, put a drop of pond or aquarium water under the microscope and let the children see it. Further explain that the tiny plants and animals they can see are larger than the germs on dirty hands. In most cases this exercise has more effect in making handwashing popular than all of the talking one does.

It has been pretty definitely proved that to be effective, hands must be washed in warm water with soap—really scrubbed—to destroy disease organisms. Schools should provide facilities where these things are available, at least before the children eat. The habit of washing after going to the toilet is extremely important—a habit that a surprisingly large number of adults have never formed. Merely dipping the fingers in water is of no value. Cases of seat worms among children have been traced to self reinfection through neglecting to wash hands.

Again, we cannot stress too much the fact that it is more important to actually train a child to observe health and safety rules than to teach him to read. A dead or sick child has no use for the three R's.

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